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THE NATURE AND SIGNIFICANCE OF MUTATIONS IN PRESENT DAY BREEDING METHODS*

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INTRODUCTION

Mutation has long been a dark curtain behind which biologists have hidden the unknown facts concerning well recognized but little understood types of variation. In recent years some progress has been made in achieving a better understanding of this obscure phenomenon, but even today there is little definite knowledge concerning how mutations arise and still less concerning why.

Variation that cannot be ascribed to segregation or to environment is usually attributed to mutation. Darwin stressed particularly the importance of small mutations, while DeVries dwelt more at length on the importance of large mutations in the process of evolution. In the former case one would expect a new species to be evolved slowly and by short gradual steps whereas in the latter case a new species might arise suddenly and in one abrupt jump. We have learned enough about mutations in the last twenty-five years to know that both small and large variations do occur and to know also something of the possible origin of these two types of variations.

It is convenient to classify mutations according to their mode of origin into two categories: (1) chromosomal aberrations and (2) gene changes. In the former case the gene itself does not undergo a change but is passively transmitted in the chromosome. The changes that are brought about by chromosomal aberrations involve the balance between genes. Modern genetics conceives the development of a character to be the end result of an interaction of many genetic factors on one hand, and environment on the other. Anything which disturbs the genetic balance of the many factors involved naturally may alter very profoundly the expression of the character. In a sense this type of variation is somewhat analogous to that following hybridization. The entity of the gene remains inviolate but the relation of the genes to one another becomes changed. The difference between segregation and recombination of genes in hybridization, and new combinations in chromosomal aberrations, is largely due to their mode of origin. In neither case have new genes arisen but in both cases new combinations have been affected.

Of a more fundamental nature are gene changes. In this case the gene itself is thought of as having undergone a change—physical or chemical

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—which makes of it a substance different from what it formerly was in the sense that carbon is different from diamond or glucose from sucrose. The gene has been referred to as the atom of biology but just as the atom of matter has yielded the proton, the electron and the photon, so it is likely that the gene itself will prove to consist of smaller units.

It seems that gene changes are the more fundamental, and have played a greater part in organic evolution, than have chromosomal aberrations. It is possible to conceive of the different species of wheat as arising from a single stem species by chromosomal aberration but it is difficult to see how maize and Kentucky Bluegrass might arise from the same family tree without the intervention of gene changes. I do not mean to infer that these two types of variation are mutually exclusive, for undoubtedly both have occurred in the evolution of many species. It does seem, however, that one should keep clearly in mind the fact that chromosomal aberration does not necessarily involve a gene change but rather a change in the balance between the genes.

Chromosomal Aberrations

Under chromosomal aberrations are included such phenomena as polyploidy, non-disjunction, deficiency, duplication, and translocation. The term polyploidy is used to cover those cases where multiples of some fundamental number of chromosomes have occurred. One may think of the chromosomes in the Jimson weed *Datura stramonium* for example, as occurring in twelve sets, the haploid being represented by a single chromosome in each set (normally the case in pollen and ovule), the diploid by two chromosomes in each set (normally the case in somatic tissue), the triploid three in each set, and the tetraploid four in each set. In polyploids the same balance between chromosome sets is found as in normal diploids, i.e., each set is represented by the same number of chromosomes except in species which have an odd number.

A different type of chromosomal aberration occurs in non-disjunction. In this case the normal balance between chromosome sets is not maintained and hence the normal balance between germinal elements is likewise not maintained. In many cases the effect of such an unbalanced condition seems to be more pronounced than the condition produced by polyploidy.

Deficiency refers to the loss of a part of a chromosome and duplication to the detachment of a section of a chromosome and its re-attachment to some other than its normal position in the same chromosome. In translocation the fragment may become attached to a different chromosome from the one whence it came. It will be convenient to consider these several classes of chromosomal aberrations somewhat more in detail under specific headings.

Haploids, triploids, and tetraploids

The gametophytes of plants and the males of certain insects are haploids. In the latter case sperm is formed without reduction division, i.e., both the sperm and the soma contain the haploid number of chromosomes usually expressed as the n number.

A few cases of haploidy among higher plants—Jimson weed, wheat, tobacco and ten weeks stock—have been reported and in these instances ex-

hibit characteristics very similar to the respective normal diploid plants except that the former are somewhat less vigorous and show a great degree of sterility.

Triploidy has been found in several plants and in a few animals. In this condition the same normal balance between chromosome sets is found as in diploids—the former is trivalent, the latter bivalent. Triploid Datura have been produced by crossing female tetraploids with male diploids. These 3n plants are similar to the 2n plants except that they are larger and, like haploids, are highly sterile. Triploid plants of Oenothera, variety semi gigas, which are supposed to have arisen by the union of 2n and n germ cells, have been described and studied. Ovules of these triploids seem to be functional regardless of the number of chromosomes; on the other hand only two classes of pollen, namely those carrying 7 or 14 chromosomes, seem to be functional.

Tetraploids, like triploids, have been reported in a number of plant species and in a few lower animals. The most critical studies of this type of variation have been made with *Datura*. Tetraploidy seems to be due to a doubling of the chromosome number through arrested cell division soon after fertilization. Tetraploidy, like the other types of variation in which the normal balance between chromosome sets is maintained, produces plants which do not differ strikingly from the diploids except in general size. Tetraploids are somewhat more sterile than diploids but not nearly so sterile as haploids or triploids and their progeny are for the most part tetraploids. When tetraploids and diploids are crossed, which is frequently difficult, a highly sterile triploid is produced, a result similar to that which often follows species crosses.

In a study of species crosses in tobacco between *Nicotiana glutinosa* and *N. tobacum* which contain 12 and 24 pairs of chromosomes, respectively, Clausen and Goodspeed verified a hypothesis presented by Winge. It was pointed out by Winge that interspecific crosses followed by successive doubling of chromosomes would give rise to geometrical rather than arithmetical ratios. Thus certain tetraploids would have the formula $2(n_1 + n_2)$ chromosomes, where n_1 and n_2 represent the haploid numbers. In the species cross reported by Clausen and Goodspeed a form was obtained which bred true for the F_1 appearance and which contained 72 chromosomes of the formula $2(12 + 24)$.

Similar cases in species crosses in wheat were reported by Tschermak and Bleier. They noted several fertile constant breeding hybrids of crosses between *Aegilops ovata* with *T. dicoccoides* and *T. durum*. These hybrids resembled the sterile forms usually obtained from such crosses. From cytological studies it was decided that they contained 28 pairs of chromosomes which is double the number of the two parents. Tschermak and Bleier believe this lends weight to Percival's view, namely, that *T. vulgare* and its allies may have descended from crosses of Aegilops and the so-called durum series.

Non-disjunction

When non-disjunction in Drosophila with its attendant genetic consequences was first reported in 1916, by Bridges, the discovery was hailed,

and rightly so, as one of the most convincing proofs of the chromosome theory of inheritance. Since that time numerous instances of this phenomenon have been described but particularly enlightening is the work of Blakeslee and his co-workers with *Datura*. In this type of variation the normal chromosome balance is disturbed. An individual may be trivalent with respect to one set of chromosomes and bivalent with respect to the other sets—a trisomic condition. In a similar manner other types of unbalanced variation may arise due to non-disjunction in one or more sets of chromosomes at time of reduction division.

The fact that the disturbed balance between chromosomes as is found for example in a 2n plus 1 individual, leads to a more profound change in the expression of characters than is brought about by polyploidy, lends support to the current hypothesis that the genetic background of a normal character is essentially the interaction of numerous genes and an upset in the balance of these genes causes an alteration of the normal character. In *Datura stramonium,* which has 12 pairs of chromosomes, twelve different kinds of 2n plus 1 plants have been produced and studied.

Some of these 2n plus 1 plants have produced two types of trisomics in which one type exhibits the features shown by the other type only in part. These types have been called primary and secondary, the latter arising from the former by a sort of reversed crossing over whereby a chromosome has lost half of its genetic material but has duplicated the other half. It is of interest in this connection to point out that in triploid female Drosophila all three chromosomes in a particular set may take part in crossing over.

Other types of unbalanced variation.

Deficiency, duplication, and translocation are other types of variation where the chromosomal balance may be disturbed. In deficiency a minute part of the chromosome, and with it certain genes, is supposed to have been lost. Most of the evidence for this type of variation is based on Drosophila and is founded on genetic, not cytological, analysis. However, the similarity of the behavior of deficiency to the condition in which a whole chromosome has been eliminated strongly suggests the possibility that a small fragment of the chromosome actually has been lost.

Duplication and translocation, strictly speaking, do not lead to an unbalanced condition of the chromosomes and therefore, except for convenience, should not be classified under unbalanced types of variation. Both of these phenomena, like deficiency, rest their case on Drosophila.

In duplication a part of a particular chromosome is supposed to have become detached and reattached at another position in the same chromosome whereas in translocation the detached part is presumed to have become reattached to some other chromosome. It is obvious that linkage relations only are involved in these two types of variation. The genes in a transported section of a chromosome are in juxtaposition to a series of loci different from those in the former location.

Significance of Chromosomal Aberration

Perhaps the most outstanding fact that has been revealed by the studies of chromosomal aberration in relation to genetics is the parallelism between

irregularities in chromosome behavior and irregularities in inheritance. What were thought to be abnormal genetic ratios have become normal when viewed through the microscope.

In general chromosomal aberrations fall into one or other of two categories. In one the normal germinal balance is preserved and in the other it is not. Haploidy, triploidy, and tetraploidy are instances of the former and monosomic, trisomic, and tetrasomic forms are instances of the latter. In general less marked variation is produced by chromosomal aberration in which germinal balance is preserved than when it is not. It is altogether likely that both of these types of variation have played an important rôle in the evolution of new species.

From the standpoint of plant breeding it is doubtful whether variation produced by chromosomal aberration will be of great importance except with forms that are propagated vegetatively. This is because variants produced by an abnormal distribution of the chromatin are in general highly unstable in their breeding behavior and this is a rather serious difficulty from the standpoint of the economic breeder. In triploidy and tetraploidy greater size of plants is frequently attained but the triploids are highly sterile. The tetraploids, or, for that matter, any forms with an even multiple of some fundamental number of chromosomes, seem to possess greater possibilities for plant breeding material than forms with an odd multiple of the fundamental number.

Monosomics, trisomics, or other forms produced by non-disjunction are even more unstable in their breeding behavior than are polyploids and for that reason perhaps offer less promise for breeding material. There is, of course, always the possibility of extracting a true breeding variety from this chromosomal conglomerate.

With plants that are readily reproduced vegetatively the situation is very different as in this case it is necessary only to find or produce a single form of exceptional merit. The triploid hyacinths together with some of their derived strains constitute a considerable proportion of the cultivated hyacinths on the market at present.

It has been shown that chromosomal aberrations may be induced to a certain extent by artificial means. In the case of plants which may be propagated vegetatively it would seem that there is a possibility of producing by chromosomal aberrations new forms of economic value.

Gene Changes

A change in an hereditary factor, commonly known as a factor mutation, is quite a different phenomenon from a chromosomal aberration. In the former case new germinal substance has been formed and in the latter case merely a rearrangement of germinal substance already existant has taken place. It would seem from the respective nature of these two types of variation that the gene change is the more important from the standpoint of the origin of new species and varieties but there is rather convincing evidence that both factor mutation and chromosomal aberration have been jointly concerned in evolution.

It may be worth while briefly to state our present notion of a gene. It is a hypothetical particle of matter borne in the chromosome, capable of reproducing itself by division and growth in the cell environment and under a given set of reactions, conditioning the expression of a character or characters. When a factor mutation occurs the characteristic attributes just mentioned are assumed by the new gene.

There is considerable interest from a theoretical standpoint as to whether the gene is the ultimate biological unit or whether it itself is composed of other units. It seems more in conformity with what has been learned regarding the organization of the physical atom and molecule to think of the gene as possessing a somewhat similar type of organization. It is easier to visualize a change in a factor if we think of that factor as composed of several primary substances rather than of a single substance.

Frequency of factor mutations

The fundamental tenets of Mendelism, together with the pure line concept, have firmly established the essential stability of the hereditary factor. It is barely possible that this idea of stability has been over-emphasized and that it will be necessary to modify somewhat our present views. That gene mutations do occur in a great variety of forms there can be no question but the real point of issue is—do they occur frequently enough to establish a basis for a system of breeding? With what is known concerning the dynamic nature of biological processes such a thing as a fixed and unchangeable gene would be more or less out of harmony. The idea that different genetic complexes exhibit different rates of mutation is plausible and in accord with the known facts.

In a study of variegated pericarp in maize Emerson discovered an instance of a frequently mutating factor and more recently Eyster has reported orange-colored seed that sometimes show variants in which some of the orange color on a particular seed has been replaced by equal and adjacent sections of red and white. The interesting suggestion is made that this is due to a segregation of contrasting substances in the gene, a suggestion which does not exactly harmonize with our present notions of somatic cell division.

Stadler, of the Missouri Agricultural Experiment Station, determined the rate of mutation of the factor C which, with certain other dominant factors, gives rise to colored aleurone in maize. Out of 55,618 chances, 6 gene mutations occurred. The rates of mutations for sh, pr, wx, and su, all endosperm factors of corn, were also determined. In 93,106 trials two mutations for the sh factor occurred but no mutation in any of the other three factors was observed among 12,000 grains.

Baur found two species of Antirrhinum to be highly constant while another species produced frequent mutations. Baur believes "small" mutations may be of considerably more importance than the so-called "large" mutations in the development of new varieties and species by natural selection.

Mutations in the small grains have been pointed out from time to time. Some of the more common ones are dwarfness, reversion to wild

types (fatuoids in oats, speltoids in wheat), and chlorophyll abnormalities. There is probably no cultivated crop in which mutations could not be found if a systematic search were made for them. Most of the mutations which have been found and reported upon are those of a striking character. It is altogether likely that many mutations which produce a relatively insignificant effect have escaped observation and yet these small heritable changes offer a source of new material for the plant breeder.

On the animal side particularly by the work of Muller and Demerec with Drosophila, it has been shown that certain genes may mutate relatively frequently. As a result of his investigation and a suggestion by Anderson, Demerec conceives a gene to be a sort of compound structure and a factor mutation to be an alteration of this compound structure.

Induced mutations

Sporadic attempts to produce heritable variation have been made from time to time ever since man became seriously interested in biology. Most of these attempts have been failures as is attested by the voluminous literature on the subject. It has been only recently that marked success in producing mutations has been attained. The most outstanding investigation in this field is the one conducted with *Drosophila melanogaster* by Muller in which it was shown that gene mutations could be induced artificially by x-rays. Significant is the fact that the mutants produced artificially were very similar to those which occur naturally but at a very, very much slower rate. These brilliant experiments have opened up a whole new field in genetics which promises interesting possibilities for the future.

Already similar experiments have been conducted on plant material. The effect of x-rays on tobacco as reported by Goodspeed and Olson at the University of California and Stadler's x-ray experiments with maize at the University of Missouri may be mentioned. The results of these investigations were similar to those obtained by Muller with Drosophila.

In the work of Goodspeed and Olson four tobacco plants bear flower buds of all ages up to anthesis were x-rayed with a Coolidge tu operated by a transformer without rectification, at an effective poter of 50,000 volts. The average distance between the target and the buds v approximately 30 cm. The time of exposure was 10, 15, and 20 minut

The x-rayed buds were allowed to set selfed-seed and approximate one-half of the plants coming from this seed were variant forms. The authors state that "these variants in general showed striking alteration of some one or of all the external morphological characters which distinguish *tabacum* var. *purpurea*. In a few cases the distinction between variant and control lay largely in the reduced fertility of the former, but in most instances such reduction in fertility was accompanied by a modification of one or more characters, appreciable but sometimes not accurately measurable. The majority of the variants were at first glance seen to be decidedly abnormal. In habit the variants were dwarf, low, or tall; the leaves were large, small, lanceolate, cordate, smooth, waxy, corrugated, dark green, gray green, petiolate—the auricles being absent, smooth, ruffled, decurrent. The flowers were very small, small, long, fluted, calycine, folded, notched,

ten-sided, light pink, pink, lively red, reddish purple, with 2–, 3–, or 4–celled ovaries. These general characterizations, distinguishing variant characters from normal, used in classification are included because they give some picture of the extent of variation observed. The majority of the variants exhibited some reduction in fertility, but only rarely were they completely sterile, while a considerable number were completely fertile."

Goodspeed and Olson have made a detailed cytological examination of several variant plants. They found evidence of chromosomal aberrations presumably brought about by the x-ray bombardment.

Significance of Gene Changes

When a gene changes, an alteration of a fundamental character of the germinal material has taken place. Each change that occurs is not only concerned with the specific effect produced on a character or characters, but it leads to a great variety of new genetic combinations.

A point mutation differs strikingly from chromosomal aberrations in that usually it may be isolated readily in a homozygous condition. The exception to this general rule is in the case of lethals or semi-lethals in which event the economic breeder is primarily concerned in eliminating them.

An explanation of heritable variation based solely on segregation and recombination of unmutable genes—in a regular manner as occurs in gametogenesis and fertilization or in an irregular manner as occurs in chromosomal aberration—is not satisfactory, particularly from the standpoint of evolution. It is much more probable that factor mutations, chromosomal aberrations and hybridization all have played important rôles.

If artificial means of inducing point mutations are successful with numerous plant and animal species it is likely that considerable will be added to our present knowledge of the gene itself. Not only does this mode of attack look promising for gene analysis but also for an insight into the cause of mutations. It seems too that such studies may give a clearer picture of what takes place in inheritance.

Mutations and Current Plant Breeding Methods

Field Crops

Current methods of breeding field crops are based on the pure line concept which postulates the essential stability of the gene. Upon the basis of available, natural plant material, it does not seem to me that these methods which have been thoroughly tested and which have given satisfactory results need be modified in any important detail because of recent discoveries in regard to mutations. While it is true that mutations do occur among field crops it is also true that mutations of economic value occur so infrequently that to base a system of breeding upon these fortuitous variants would hardly be justified. Present methods of breeding are quite satisfactory as far as they go. What may be needed is the addition of a new technique to induce heritable variation. On the other hand it is probable that some forms naturally produce frequent small heritable changes which offer a constant source of new material for the plant breeder.

For many years hybridization has been practised as the only well established means of creating hereditary variations among which selection for

the desired combination of characters has been made. The time is hardly ripe for abandoning this well seasoned method; however, in view of the interesting results which have recently been obtained in experiments to induce heritable variations with x-rays, the plant breeder cannot afford to disregard entirely this possible avenue of attack. Many new problems are at once suggested. Will crop plants generally respond to the x-ray treatment? Are mutations artificially induced as stable as those which occur naturally? Are light rays of short wave length the only really effective means of artificially inducing mutations? If so, what is the correct dosage to obtain a maximum number of mutations with specific crops? Will the frequency of variants which have economic value be great enough to justify the procedure? It will be necessary to answer these questions and many additional ones before an appraisal of this new possible plant breeding tool may be made. It is undoubtedly true that the experiments of Muller with Drosophila and Goodspeed and Olson with tobacco have opened up a new field which presents interesting possibilities but likely it will be some time before the x-ray machine will be as essential a part of the working equipment of the plant breeder as tweezers and paper bags now are.

Many of the inheritance studies which have been conducted with field crops have been concerned with mutant characters of relatively recent origin. In the case of naturally self-fertilized crops, mutations which are deleterious to normal growth and reproduction have been largely eliminated but in cross fertilized crops the situation is quite different. When a recessive mutation arises in a naturally cross fertilized crop it may be carried indefinitely in the heterozygous condition. Artificial self-pollination reveals many such mutants.

The extensive genetic studies with maize have been concerned chiefly with specific characters which have been disclosed by artificial self-fertilization. The investigations with selfed lines show that recessive mutations are appearing from time to time and some of these when in a homozygous condition prevent normal growth. It seems to me that the investigator who is interested in the economic side of maize breeding might well give more of his time to a study of the influence on yield of these deleterious characters when in a heterozygous condition. It is reasonable to suppose that there is considerable difference between different recessive characters in this respect.

As an instance of this a defective endosperm character which appeared in one of the selfed strains of corn studied at the West Virginia station, behaved in a rather interesting manner. Plants from homozygous defective seeds were decidedly inferior, lacked vigor, and produced very little seed. Plants from heterozygous defective seed could not be distinguished from plants coming from seed of the same selfed line but not carrying the gene for defective. However, the yield of the pure normal plants was on the average significantly greater than the average yield of the heterozygous defective plants in each of the two years the experiment was conducted.

Modern practices in maize breeding are based to some extent on the assumption that characters which when in a homozygous condition interfere with normal metabolism and reproduction do likewise when in a heterzygous condition. This may or may not be true. We are spending a great

deal of money and time in eliminating so-called defective characters, without very much knowledge concerning their relative influence when carried, as they ordinarily are, in a heterozygous condition. It seems likely that some of these characters will be found to be much more important than others in their influence on production.

Most of the mutations which occur in nature are, apparently, recessive and it is of interest that those which have been induced artificially in Drosophila and tobacco are similar in this respect. Many of these recessives are lethal or semi-lethal in their effect, particularly those in Drosophila which have been most intensively studied. In addition to recessives, dominant variants also occur but they seem to be much more infrequent. There would be a natural tendency to eliminate dominant lethals or semi-lethals as they appeared. Cross fertilization permits an accumulation of recessive mutants which may be more or less undesirable in a species; on the other hand in a self-fertilized species these mutants, like dominant lethals or semi-lethals, tend to be eliminated as they appear.

In oats the occurrence of mutations has been observed a number of times. One of the most common is the fatuoid form. Most plant breeders working with this crop have observed this aberrant form in their cultures. The exact nature of the mutation which causes this interesting phenomenon is in dispute but most workers are agreed that it is due to a mutation of some kind and not to natural crossing. This conclusion is of some importance as it suggests the only method of eliminating the form if indeed it can be eliminated.

Oat varieties generally belonging to the Byzantina group have a notorious reputation for becoming impure. What is the cause? Is it due to natural crossing, to mutation, or perchance to both? It is probable that different crops or even different varieties of the same crop will show diverse rates of mutation depending somewhat on the stability of the germ plasm. Some varieties of *A. sativa* seem to "throw" more fatuoid forms than do other varieties.

From the foregoing discussion it would appear that among field crops mutations of economic value appear so rarely that one would hardly be justified in basing a system of breeding upon their chance occurrence. On the other hand if it is possible to speed up, by artificial means, the rate of which mutations appear and they prove to be relatively stable, such a method may prove to be a valuable one for inducing heritable variation. In any event present plant breeding methods will continue to be used to evaluate new forms regardless of whether they have been produced by introduction, selection, hybridization, or mutation.

Horticultural Crops

In general, the breeder of horticultural crops has, perhaps, been more observant of mutations than the breeder of field crops. With citrus fruits some definite results have been obtained by isolating favorable mutations. Many of the horticultural plants are propagated vegetatively and this is a distinct advantage from the standpoint of perpetuation of valuable muta-

tions. When a desirable variant appears, regardless of the manner in which it was produced, it may by this method be increased and made available for economic purposes. For this reason it seems that the x-ray, if it proves effective in plants, will hold out even greater possibilities to the breeder of horticultural crops than to the breeder of field crops.

Conclusion

At the present time there is too little information even to permit an estimate of the value of inducing mutation by artificial means as a method of breeding economic plants. It does, however, seem to offer interesting possibilities. It would be well for those who have the facilities, to make excursions into the new field as it is only by so doing that we may arrive at an appraisal of the value of the new method. Regardless of the outcome, I am sure that we shall continue to use our present methods of breeding, which are based on the pure line concept.

BOOK REVIEW

The Newer Knowledge of Bacteriology and Immunology. Edited by Edwin O. Jordan and I. S. Falk. (University of Chicago Press. Pp. 1196. Price $10.00.)

In this work of nearly 1,200 pages are contained eighty-three essays covering a wide range of special subjects of the utmost interest to bacteriologists and immunologists. The purpose of the preparation of the book has been, as indicated in the preface, to obtain authoritative critical reviews of topics in which, at the present time, interest is particularly keen and investigation most active. To this end eighty-two authors have contributed chapters, producing an unique volume and one for which microbiologists will be most grateful. With the mass of publications appearing at the present day there is, more than ever, urgent need for critical reviewing of data and for a summing up of the present state of our knowledge of special phases of bacteriology and immunology. The editors have chosen a wide range of topics, have allowed the contributors the utmost latitude, and have included, in some cases, papers from authors with opposing views to set forth both sides of questions where divergence of opinion exists.

To discuss individual chapters is not possible in a short review. They vary, naturally, in quality. Some are indeed excellent, furnishing brilliant summaries of our present knowledge and progress in such a way that definite landmarks may be seen out of the maze of current publication and diversity of view.

For the agriculturist the book will be welcomed, not only on account of the chapters treating of soil, food and dairy bacteriology, but even more so, in our opinion, for those on allied, though not directly agricultural topics and on pure bacteriology, progress in which the agricultural specialist naturally has less opportunity to follow as closely. Yet knowledge of these is indispensable if he is to apply microbiology most successfully. For him as much as for bacteriologists in general the book will be found exceedingly valuable, and its dissimilarity in style, both as regards conception and execution, from the usual academic text-book will further strengthen its appeal to the reader.

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THE CAUSE AND CURE FOR FERMENTED HONEY

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The spoiling of any finished product which is ready to market always represents a loss. Honey is no exception to this rule. At one time many farmers kept a few colonies of bees to produce honey for home consumption and very little of it was sold. Most of the honey was consumed in the comb and little was extracted. If spoilage did occur, the loss was small and little attention was paid to it. However, owing chiefly to bee diseases, this condition has gradually changed until to-day the bulk of the honey is produced in large apiaries. Likewise most of the honey is extracted and often stored for a period of time to await a favorable market or is gradually released to prevent flooding the market. When honey is stored in large quantities, fermentation is more noticeable than if the same quantity was stored in many places in smaller quantities, and often represents a considerable economic loss.

History of Fermented Honey

Boutroux, a Frenchman, as early as 1884 called attention to the fact that the nectar of flowers might have yeasts present, but this was mere speculation, and it was not until some years later that his speculations were investigated by Hilkenbach, a German, who in 1911 made a study of the yeasts found in nectar and their dissemination in nature. A little later, in 1912, Reukauf observed a cross-form yeast in nectar and advanced a theory that every kind of plant harbored a different kind of fungus. Schuster and Ulehla disproved this theory in 1913. They showed that a great variety of flowers, at least ten different genera, harbored the same yeast.

Grüss in 1917 next investigated as to how the yeast might be transferred or transmitted to the nectar of the flower. He showed the adaptability of the proboscis of the bee to the structure of the flower and showed that the same yeasts were present in both the papillary of the blossoms containing nectar and in the proboscis of the honey and bumble bee. It was also found in the fore and honey stomach of the bee. He was of the opinion that the yeast was laid in by the bees with the honey and larva food in the covered honey comb.

Schoellerhorn, a Frenchman, in 1919 made a very extended study of the distribution of yeasts in flowers, and his observations are both interesting and instructive. He found that the nectar of greenhouse plants, as a result of the absence of insect visits, was sterile; in flowers where the nectar was inaccessible, as in narcissus, it was likewise sterile; Alpine flowers were less infected than the flowers of the lower plain regions; closed flowers contained sterile nectar; yeasts spread by dusts were different than those spread by bees. One of his most interesting observations was that the same yeasts are found in the nectar of flowers of the same species collected in different spots at the same period, and are found the next year at the same period in the flowers of the same plants.

Microörganisms Found in Honey and Bees.

Richter isolated a yeast which he found in honey undergoing alcoholic fermentation. Klöcker recovered a species of yeast from the body of bees. P. Bruce White studied the alimentary tract of some 1200 bees and observed smears of the intestinal contents of a great many more and found four main types of bacteria but said nothing about finding yeasts. G. F. White isolated three yeasts from diseased brood. It will be seen that there is not much information concerning the microbial flora of bees and honey.

Strange Theories Concerning Microörganisms in Honey.

Before much was known concerning the microörganisms and their significance in nectar and honey, several theories were advanced to explain their probable use. One of the suggestions was that the microörganisms inverted the nectar. Another was that it was the microörganisms present in nectar and honey that were responsible for some of the diseases of bees. However, we now know the causative organism of some of the diseases of bees and it is not any of those commonly found in nectar or honey.

What Causes Honey to Spoil?

Spoiled honey is not uncommon. In some years there seems to be more spoiled honey than in others. In years when there is a great deal of rain, it is a general observation amongst beekeepers, that more honey spoils than in a dry year. It is also common knowledge that unripe honey usually spoils unless it is concentrated or heated to a temperature sufficiently high to kill the microörganisms present. The above are common observations and general knowledge to most beekeepers.

Now just what causes the honey to spoil is not generally known. A study of the cause has been under investigation at the Michigan Agricultural Experiment Station by the author and a co-worker, Ramon Quinet, for the past several years and the detailed results are now available in Technical Bulletin 92. In this work samples of fermented honey were submitted for analysis from many parts of the United States and Canada. All of the samples submitted were analyzed for moisture content and microorganisms. The moisture content of a majority of the samples was found to be greater than 21 per cent, although several of the samples tested showed a moisture content as low as 17 per cent. Various experiments were carried out with sterile honey inoculated with yeasts obtained from spoiled honey and it was found that as soon as the moisture content of the honey reached 21 per cent or more fermentation started.

Extracted honey was placed in a moist atmosphere and it was found that it absorbed water. The amount of water absorbed in some cases was as much as 33 per cent. Comb honey on the other hand absorbed moisture very slowly, the greatest increase noted being 5.68 per cent. Comb honey when placed in a dry atmosphere likewise lost moisture very slowly. One experiment carried out over a period of seven years showed that the amount of moisture lost during this time was only 7.77 per cent. As a result of the above experiment the conclusion was reached that there is a very intimate relationship between the moisture content of extracted honey and its fermentation or spoilage.

A Theory Regarding the Spoilage of Honey

A bacteriological analysis of many samples of fermented and unfermented honey showed that practically all samples contained yeasts, and that when sufficient moisture was present these yeasts were capable of fermenting the honey. From these observations it is believed that when unripe honey is extracted and placed in storage, or when honey is stored in damp places, enough moisture will collect on the surface to dilute the top layers of the honey to a degree suitable for the growth of the yeasts present, and as a result they grow and cause fermentation or spoilage. Honey should, therefore, be stored in a cool dry place and closely observed for spoilage. It is easy to detect containers that are undergoing fermentation by their appearance. The yeasts in growing convert a part of the sugar into alcohol and carbon dioxide. It is the carbon dioxide which is given off in the form of a gas which causes the cans or containers to swell and they are readily detected. The amount of alcohol ranged from 3.63 to 6.9 per cent by volume.

Nature of Microörganisms Found in Honey

The nature of the material causing the fermentation was found to be little plants, invisible to the naked eye but readily detected by proper bacteriological methods. By means of the proper food these plants may be grown by a bacteriologist in a bacteriological garden much the same as a florist would grow flowers in a greenhouse. By the aid of a microscope these plants, called yeasts, may be studied and properly classified in the plant kingdom. Twenty-five yeasts were isolated from honey and classified. It was found that they could be grouped into two different genera and five different species.

How to Prevent Honey from Spoiling

Experiments were conducted to ascertain the degree of heat necessary to kill or prevent the growth of these yeasts in honey. It was found that by heating honey containing yeasts to a temperature of 145°F. for 30 minutes no spoilage occurred. If there is any doubt in the beekeeper's mind as to whether honey will keep or not, this would be a safe practice to follow. Heat is the best method to use to prevent spoilage, since the Pure Food laws prohibit the use of any chemicals for food preservation except benzoic acid or benzoate of soda. Only well ripened honey should be placed in storage. Unripe honey should be evaporated until the excess water is removed before being stored. It should then be heated to a temperature of 145°F. for 30 minutes. This will help to evaporate moisture and kill the yeasts present.

Summary

To sum up the information which is now available concerning fermented honey, it may be said that minute plants, technically known as yeasts, are found in both unfermented and fermented honey. These yeasts when isolated and placed in sterile honey are capable of fermenting it. Honey when placed in a moist atmosphere absorbs water. It may absorb sufficient water to cause fermentation if the proper yeasts are present. Honey should, therefore, be stored in a cool dry place. Unripe honey is more apt to ferment than properly ripened honey. For this reason the excess moisture should be evaporated before it is placed in storage or sold. Spoilage in honey may be prevented by heating it to a temperature of 145°F. for a period of 30 minutes.

YELLOW SEEDLINGS IN WHEAT

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Chlorophyll deficiencies in seedlings have been reported frequently in recent years. Albino seedlings are perhaps the most common but cases of virescent whites, virescent yellows and yellows have been studied. The writers observed yellow seedlings in a wheat cross, and since, as far as they know, a similar case has not been reported, they prepared the preent paper giving the results of their study.

Previous Work

The appearance of yellow seedlings in self-fertilized lines of corn was studied by Lindstrom (*3, 4*). He found two genes responsible for the formation of the yellow pigments, both being recessive and strictly Mendelian in inheritance. They differed in the intensity of the yellow color produced and in their relationship to a gene which entirely inhibits plant color.

Nilsson-Ehle (*6*) found that the appearance of yellow seedlings in crosses between certain lines of barley was explained satisfactorily on the basis of a recessive genetic factor for the production of yellow pigment. In other crosses he found that a different gene for yellow was responsible.

Stroman and Mahoney (*7*) reported yellow seedlings in cotton crosses. These seedlings showed light greenish yellow cotyledons as they emerged from the soil. The small amount of green pigment soon disappeared and the cotyledons became distinctly yellow. The expression of the yellow character was shown to depend upon the presence of two recessive genes in the homozygous condition.

Experimental Results

In the course of the wheat breeding work at Saskatoon the two *dicoccum* varieties Khapli and Early Emmer were crossed. The F_1 was grown in 1926, the seedling plants being of the same normal green color as the parent varieties which grew adjacent. In 1927 the F_2 was grown. Occasional bright yellow seedlings appeared among the green ones. The yellow seedlings appeared to be normal excepting for their lack of chlorophyll. In a few days they died, just as albino seedlings do, and every attempt to keep them alive by transferring them to a greenhouse was unsuccessful.

A count of the F_2 seedlings showed 2441 green and 145 yellow. Fitting these figures to a calculated 15:1 ratio gave a deviation of 16.6 ± 8.3 from the expected. The paucity of yellow individuals, while quite marked, could easily have been due to chance. The results indicated the presence of two recessive genes for the production of yellow pigment and the suppression of chlorophyll development.

Progenies of 71 F_2 plants of this cross, all of which were normally green in the seedling stage, were grown in the greenhouse in October 1927. The numbers of green and yellow seedlings in each family are given in Table 1. The non-appearance of yellows in small families does not necessarily indicate

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inability to produce yellows, for a few of them appeared to segregate according to the dihybrid ratio 15:1. Therefore it was decided to leave out of consideration all families with less than 21 seedlings, this number being chosen quite arbitrarily. Of the 71 progenies 16 were eliminated on this basis.

TABLE 1.—*Segregation of green and yellow seedlngs in F_3 progenies of the cross Khapli X Early Emmer.*

F_2 plant number	Number of F_3 seedlings Green	Yellow	Probable ratio	F_2 plant number	Number of F_3 seedlings Green	Yellow	Probable ratio
1	33	0		424	23	0	
2	39	0		425	20	0	*
3	25	9	3 : 1	426	26	0	
4	35	3	15 : 1	427	27	0	
5	31	0		428	27	0	
6	36	0		429	20	0	*
7	46	3	15 : 1	430	18	0	*
8	36	0		431	24	5	3 : 1
9	40	12	3 : 1	432	13	0	*
10	65	0		433	19	7	3 : 1
11	55	0		434	18	0	*
12	73	0		435	19	0	*
13	38	0		436	23	1	15 : 1
14	52	0		437	24	0	
15	50	0		438	19	0	*
16	58	0		439	27	0	
17	54	11	3 : 1	440	20	4	3 : 1
18	36	0		441	20	0	*
19	63	0		442	15	3	
20	71	3	15 : 1	443	15	0	*
21	13	0	*	444	23	0	
22	35	12	3 : 1	445	28	0	
23	40	0		446	23	0	
24	54	0		447	8	0	*
25	48	17	3 : 1	448	23	1	15 : 1
410	18	2	*	449	13	3	*
412	21	0		450	25	0	
413	27	0		451	22	0	
414	12	2	*	452	21	5	3 : 1
415	22	0		453	19	0	*
416	22	0		454	22	0	
417	25	1	15 : 1	455	19	6	3 : 1
418	23	4	3 : 1	456	19	8	3 : 1
419	30	0		457	23	0	
420	21	9	3 : 1	458	30	3	15 : 1
421	23	0		459	25	0	
422	28	1	15 : 1	460	20	0	*
423	25	0					

* Left out of consideration owing to small size of progeny.

The numbers in the segregating families seemed to fit the ordinary Mendelian ratios 3:1 and 15:1. To determine the validity of assuming the ratios for the various families as shown in Table 1, it was desirable to study the fit of the observed numbers of green and yellow seedlings in each family to the expected numbers. This can be determined by Pearson's χ^2 method as used recently by Yule (*8*, p. 264), Fisher (*1*, p. 82) and by Kirk and Immer (*2*), and set forth in Table 2. With n equalling 21 (the number of the degrees of freedom), P according to Fisher's (*1*) table of χ_2 is .985. The exceptionally good fit shows that the classification of families according to the ratios 3:1 and 15:1 was accurate.

TABLE 2.—*Test for goodness of fit of the observed numbers of green and yellow seedlings to the expected numbers in F_3 progenies of Khapli X Early Emmer.*

F_2 plant number	O	C	O–C	$(O-C)^2$	$\frac{(O-C)^2}{C}$
3	25	25.500	.500	.250	.010
	9	8.500	.500	.250	.029
4	35	35.625	.625	.391	.011
	3	2.375	.625	.391	.165
7	46	45.938	.062	.004	.001
	3	3.062	.062	.004	.001
9	40	39.000	1.000	1.000	.026
	12	13.000	1.000	1.000	.077
17	54	48.750	5.250	27,563	.565
	11	16.250	5.250	27.563	1.696
20	71	69.375	1.625	2.641	.038
	3	4.625	1.625	2.641	.571
22	35	35.250	.250	.063	.002
	12	11.750	.250	.063	.005
25	48	48.750	.750	.563	.011
	17	16.250	.750	.563	.035
417	25	24.375	.625	.391	.016
	1	1.625	.625	.391	.240
418	23	20.250	2.750	7.563	.373
	4	6.750	2.750	7.563	1.120
420	21	22.500	1.500	2.250	.100
	9	7.500	1.500	2.250	.300
422	28	27.188	.812	.659	.024
	1	1.812	.812	.659	.364
431	24	21.750	2.250	5.063	.233
	5	7.250	2.250	5.063	.698
433	19	19.500	.500	.250	.013
	7	6.500	.500	.250	.038
436	23	22.500	.500	.250	.011
	1	1.500	.500	.250	.167
440	20	18.000	2.000	4.000	.222
	4	6.000	2.000	4.000	.667
448	23	22.500	.500	.250	.011
	1	1.500	.500	.250	.167
452	21	19.500	1.500	2.250	.115
	5	6.500	1.500	2.250	.346
455	19	18.750	.250	.625	.033
	6	6.250	.250	.625	.100
456	19	20.250	1.250	1.563	.077
	8	6.750	1.250	1.563	.208
458	30	30.938	.938	.880	.028
	3	2.062	.938	.880	.427
	n = 21			$\chi^2 = 9.341$	P = .985

The fit may also be tested by treating the families segregating according to the 3:1 ratio separately from those showing an approximate 15:1 ratio. As expected the results were practically the same, P being .896 for the 3:1 families and .970 for the 15:1 families.

A further check on the results may be obtained by testing the total numbers of green and yellow seedlings in the 3:1 and 15:1 segregating families for fit to the expected numbers. The families that segregated in a probable 3:1 ratio showed 368 green seedlings and 109 yellow, where 357.75 and 119.25 were expected. The deviation (10.25) is less than twice the probable error (6.38) and cannot be considered significant. In the families that gave results approaching a 15:1 ratio there were 281 green and 16 yellow seedlings. The expected numbers were 278.44 and 18.56 respectively. The deviation (2.56) is less than the probable error (2.81) indicating a good fit between the obtained and calculated values.

The following hypothesis seems to suit the results. Recessive genes a and b for the inhibition of chlorophyll formation under normal field conditions are carried by Khapli and Early Emmer, respectively. When these genes are both present in the homozygous condition the seedlings are yellow.

According to this hypothesis seven-fifteenths of the plants that were green as seedlings should produce green seedlings only, four-fifteenths should give a 3:1 ratio of green and yellow and four-fifteenths should give a 15:1 ratio of green and yellow. The obtained figures for these three classes were 37, 13, and 8. The expected figures were 27.07, 15.47 and 15.47. The goodness of fit was tested by the χ^2 method. P equals .023 indicating a poor fit. The fit may also be tested by the formula $\pm .6745 \sqrt{p.k.n.}$ There were 37 families giving only green seedlings and 21 that segregated. The expected numbers were 27.07 and 30.93, respectively. The deviation is 3.88 times the probable error again indicating a poor fit. Clearly there were too few segregating families.

Deficiency of Yellow Seedlings

In both the F_2 and F_3 populations the number of yellows was less than expected, although in no single case could the deficiency be considered significant. The combined tendency toward paucity of yellows may be mathematically measured by the use of Student's method. This is done in Table 3. With Z equalling 5.072 the odds are 105 to 1 that the number of yellow seedlings was distinctly less than expected.

TABLE 3.—*The determination of the significance of the deficiency in the number of yellow seedlings, by Student's method.*

Hybrid generation	Segregation ratio	Number of yellow seedlings Obtained	Expected	Difference	% Diff.	(% Diff.)^2
F_2	15:1	145	161.60	16.60	10.27	105.47
F_3	3:1	109	119.25	10.25	8.60	73.96
F_3	15:1	16	18.56	2.56	13.79	190.16
					3 | 32.66	3 | 369.59
					10.887	123.20

$$S.D. = \sqrt{123.20 - (10.89)^2} = 2.147$$

$$\frac{10.887}{2.147} = 5.072 = Z$$

Effect of Different Light Conditions on the Development of *aabb* Seedlings

The *aabb* seedlings were able to develop a certain amount of chlorophyll under unusual light conditions in the greenhouse. In the field in June 1927 the *aabb* seedlings were bright yellow with not a trace of chlorophyll observable. The yellow seedlings in the F_3 progenies grown in the greenhouse in October 1927 had a slight amount of chlorophyll and did not die as quickly as those in the field. Seed of a number of F_3 families was sown in the greenhouse in December 1927. The *aabb* seedlings in this case were pale green. They were decidedly subnormal in their development of chlorophyll and were easily distinguished from normal green seedlings. In their early growth they were as healthy and vigorous as normal plants. Later they became increasingly yellowish and finally died long before reaching the heading stage.

In order to learn more about the inhibitory action of factors *a* and *b* seedlings from F_3 families that had produced progeny of the constitution *aabb* were raised under different light conditions. One lot was kept in semi-darkness until the seedlings were three weeks old. The *aabb* seedlings were light green. Another lot was kept under a moderate intensity of light at night and had daylight during the day. The *aabb* seedlings were light green, a shade more yellowish than the first lot if anything. A third lot had daylight during the day and was under strong illumination at night. Here the *aabb* seedlings were even more yellowish than the second lot although still being classed as light green. It appeared that less development of chlorophyll took place as the intensity and duration of exposure to light were increased.

Discussion

Several interesting points have arisen in connection with the results given in this paper. Comparatively few similar cases have been reported in plants. As far as the writers know the occurrence of yellow seedlings in Mendelian ratios in a wheat cross has not been reported previously. The F_2 and F_3 results show definitely that two main genetic factors are responsible for the non-development of chlorophyll in the yellow seedlings. It is also apparent that these factors are recessive.

The number of yellow seedlings and of families producing yellows was distinctly less than expected as shown by various tests. This is difficult to explain. In view of the vigorous early growth of all of the yellow seedlings it is unlikely that the paucity of yellows was caused by zygotic lethals. Various instances have been reported of deficiency in the numbers of recessive forms. Nagai (*5*) reported cases of this kind in his studies of mutations in rice. He found that in practically every case where segregation with respect to two mutant characters was being studied, the number of individuals homozygous for both recessives was smaller than was expected. By determining the fertility of homozygous normal and of heterozygous hybrids he found that there was no zygotic elimination immediately after the fertilization of heter-

ozygous plants. Furthermore the proportions of seedlings that grew to maturity was about the same in the progenies of homozygous as in those of heterozygous plants. It was suggested that inequalities occurred in the proportions of gametes formed. Similarly in the present study the cause of the deficiency in the number of yellow seedlings appears to be associated with the gametes and not with the zygotes. Whether it be a matter of unequal production of gametes, differential viability of gametes, differential mating of gametes or some other disturbing factor is a matter of conjecture at present.

Under unnatural light conditions in the greenhouse the *aabb* seedlings developed some chlorophyll, this being most evident where the intensity and duration of exposure to light were the least. It is quite possible that other environmental factors, such as temperature and humidity, were partly responsible for the formation of chlorophyll in the greenhouse. While many cases of abnormal chlorophyll inheritance have been studied there is little known about the reaction under different environmental conditions of the genetic factors that govern such phenomena. There is here a fertile field for further research.

Summary

1. In the F_2 generation of a cross between Khapli and Early Emmer, two varieties of *Triticum dicoccum*, approximately one-sixteenth of the seedlings were bright yellow in color, apparently healthy but lacking chlorophyll; these seedlings died when they had exhausted the food supply of their endosperms. In F_3 some progenies consisted solely of green seedlings, others were composed of green and yellow seedlings approximately in the ratios 3:1 and 15:1.

2. The results showed that two recessive genes, designated *a* and *b*, for the inhibition of chlorophyll development are carried by Khapli and Emmer respectively. When these genes are present in the homozygous condition the seedlings are yellow.

3. In both F_2 and F_3 the number of yellow seedlings was less than expected, and in F_3 there was deficiency in the number of families which segregated for green and yellow plants.

4. When grown in the greenhouse in the fall and winter the yellow seedlings developed some chlorophyll, this being most evident where the intensity and duration of exposure to light were the least.

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BOOK REVIEW

Fixation of Atmospheric Nitrogen. By Frank A. Ernst. (D. Van Nostrand Co., New York, 1928. Pp. 154. Price $2.50.)

In presenting this book, the author disclaims any attempt to write an exhaustive treatise designed for the scientist or technician associated with work dealing with nitrogen fixation. The volume is intended rather for the technical man engaged in other branches of science who wishes general but authentic information on this subject, and who may, for more detailed data, seek other and more technical writings on the subject.

The author, formerly with the Nitrate Division of the U.S. Army Ordnance Bureau, and at present with the Fixed Nitrogen Research Laboratory, U.S. Dept. of Agriculture, is able to speak with authority on the subject of fixation of nitrogen. In the course of seven chapters he deals successively with the subjects of nitrogen, atmospheric nitrogen fixation, the arc process, the cyanamide process, the direct synthetic ammonia process, economic considerations and ammonia conversion products. A final chapter deals with statistics of the industry. Following the text appears a succession of informative appendices containing tables of output of nitrogen by various methods of fixation, import and export figures, production costs, etc., a bibliography and index completing the volume.

In comparatively small compass the author sums up our present knowledge of the subject in very readable fashion, and for the general technical reader who, though but indirectly interested in the subject, yet wishes to familiarize himself with the chief principles of nitrogen fixation, this will be found a very useful book.

A.G.L.

WINTER RYE FOR WESTERN CANADA*

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Origin of Rye

Vavilov (*15*), who determines the place of origin of any crop by endeavoring to discover the place at which the greatest diversity of forms appears, gives Transcaucasia and Asia Minor as the home of rye. The weed rye which is native there may, he suggests, have been grown with wheat or barley and its value as a food crop discovered.

The cultivated plant as we now have it is the result of much natural and human selection. "In Asia Minor and Transcaucasia", says Vavilov, "not only a great number of forms have been found but many dominant forms, as red-eared, brown-eared and even black-eared forms as well as varieties with strongly marked pubescence. In its progress from the principal geographic genetical bases towards the periphery the cultivated plant type becomes lighter in color; Europe is chiefly characterized by white-eared rye." "The plant breeder", he continues, "must know how to choose among the diversity of chiefly dominant genes those which are able to serve his purpose. It is very probable that the most interesting combinations for European cultivation are the recessive ones."

In his opinion of the value of recessive characters Vavilov differs from many experienced plant breeders, who find that injurious factors are usually recessive.

Genetic Constitution of Rye

Rye has been usually described as possessing seven pairs of chromosomes. In 1924 a Japanese worker, Kasuo Gotoh (*5*) reported finding plants with eight chromosome pairs. These were derived from seven chromosome plants by diagonal splitting of one pair.

This finding was corroborated by Belling (*2*) for rye grown in America. He states, "Plants from a field of rye in Long Island also showed either seven pairs of chromosomes or eight pairs. In one case all the grains of an ear had germinated together, and those plants examined had eight pairs of chromosomes." Apparently no work has yet been reported on the effect of such chromosome splitting upon the development of the plant.

Rye is a comparatively new crop in Saskatchewan. In 1910 the combined area of fall and spring rye was 754 acres, in 1915 it was 2,700 acres. The area was greatly increased after the end of the war, 1,200,000 acres being sown in 1921. Prices fell and the acreage was for a time reduced but the tendency now seems to be towards a steady increase. Winter rye occupies a much larger area than spring rye. The area in 1927 in winter rye alone was 288,450 acres and the yield was estimated at 6,461,000 bushels.

*Presented in partial fulfilment of the requirements for the degree of Master of Science at the University of Saskatchewan.

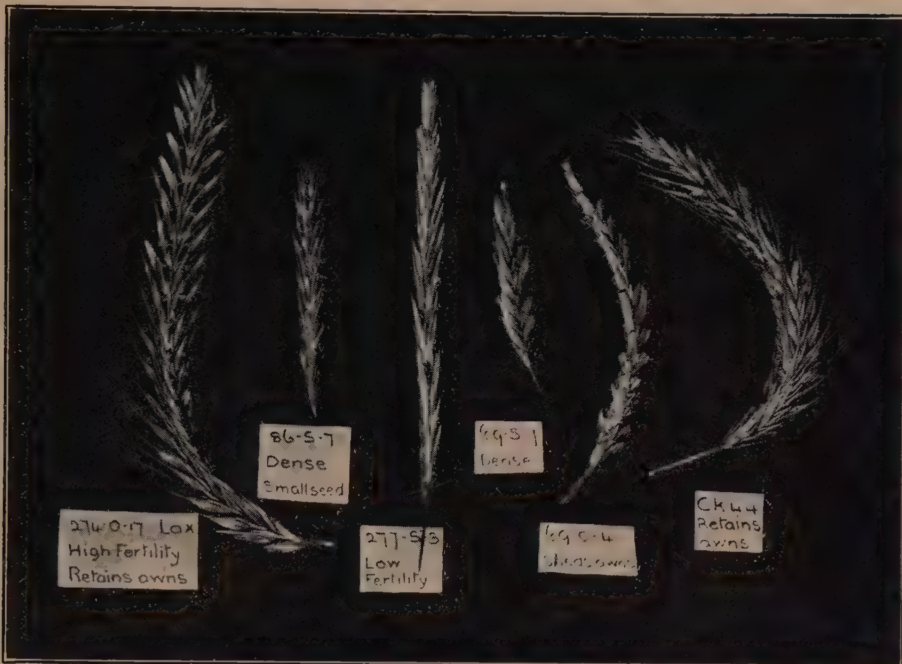

PLATE 1. Heads of rye showing various types.

VARIATION IN RYE

Rye is a plant chiefly cross-fertilized and the majority of plants are heterozygous for many characters. No individual plant can be counted upon to breed true and as might be expected, a field of rye usually contains a very wide variety of types.

Heads of high fertility and heads of low fertility, yellow, green and brown seed, dense heads and lax heads, small seed and large seed, strong straw and weak straw, awns retained until the seed is mature, awns readily broken off, broad leaves and narrow leaves, pale leaves and dark leaves, resistance and susceptibility to the various plant diseases; these are some of the variations found in every field of rye.

Many of these types are plainly undesirable. If they come by inheritance and not merely as a result of environment, it may be possible to eliminate unwanted types. Such work has been done in Europe and great improvement has been made by selection.

A selected strain must be kept free from pollination by inferior strains. For this reason growers in European countries make a practice of renewing their seed from the original source after a few generations have been grown. The improvement of rye by selection has for this reason been very profitable to successful growers.

METHODS OF IMPROVEMENT

1. *Head Selection*—Careful and methodical improvement of rye may be dated from 1867 when Dr. Wilhelm Rimpau commenced his work at Schlanstedt. The method is reported by De Vries (*4*) who visited Rimpau

in 1876. "At the time of harvest he inspected, as he told me, a large number of his rye fields and selected all the ears which seemed to him to surpass the others noticeably. He brought home a handful of them, repeated the trial and mixed their seeds. The seeds were sown the next year and in the harvest the same selection of the best ears was repeated. Each year in the same way the best ears were chosen for the continuance of the elite strain and after the exclusion of all ears of minor value the remainder were multiplied without further selection." The rye grown by Rimpau under the name of Schlanstedter rye became the leading variety of Europe.

2. *Selection on performance of progeny*—A second method of selection was that followed by von Lochow at Petkus. He judged the value of each plant by the performance of its progeny. He sowed a portion of the seed from each plant in an individual plot and retained a portion, which would be used as elite seed if the strain seemed promising. It is worthy of note that since the reserved seed resulted from open pollination only the female parent was definitely known. The Petkuser rye succeeded Schlanstedter as the most popular rye in Europe.

3. *Selection after inbreeding*—The foregoing methods have the disadvantage that the plants grown are subject to open pollination and therefore each flower on a given plant may be fertilized by pollen from a different plant; only half the hereditary constitution of each seed is known. A third method of rye breeding is therefore now in use. This consists in the exclusion of foreign pollen by the use of a parchment bag in which one or more heads of a single plant are enclosed. The inbred plants usually show some loss of vigor but this loss may be overcome by re-crossing the selected lines. Steglich and Pieper (*11*) report after fourteen years of inbreeding work that "a single crossing is apparently adequate to overcome the constitutional losses in inbred strains."

The advantages of this method are several:

(1) Recessive abnormalities are eliminated.

(2) Strains homozygous for desired inherited characters are obtained. In the case of characters governed by a single factor difference, this process is quite rapid.

(3) Recombinations may be made which give a large amount of hybrid vigor.

The disadvantages lie in the fact that the majority of rye plants are highly self-sterile. The proportion of self-sterile plants encountered at Saskatoon is probably typical. In the first year of selfing fifty per cent of the plants showed complete self-sterility. Several lines that gave only a few seeds in 1925 gave no seeds when selfed in 1926. The experiment is thus confined to the descendants of less than half of the plants originally selected. A test made in 1926, however, showed the plants from these lines, whether from self-pollinated or open fertilized seeds, to be equal or superior to the Dakold material used as checks in both germination and winter survival.

TABLE 1.—*Viability and winter hardiness of self-fertile lines.*

	Seeds	Stand Oct.	Stand June	Germ. %	Winter Survival %
Seeds from self-pollinated heads	970	903	808	93.1	89.1
Open pollinated heads from same plants	540	434	385	80.4	88.7
Dakold Checks	740	545	467	73.6	85.7

Self-sterility is apparently due to a lack of stimulation of pollen-tube growth when self-fertilization takes place. Jost (*7*) reports of open fertilized rye plants: "Pollen tubes penetrated the micropyle in about eight hours after pollination, although after self-pollination the pollen tubes had merely reached the base of the pistil after twenty-four hours."

MATERIAL USED

The variety chosen for use was Dakold winter rye (Sask. No. 295). Dakold is described by Stoa (*12*) as "a dark, small seeded, early maturing variety developed at the North Dakota station in 1902." The variety as grown at Saskatoon in 1927 is to the extent of about 80 per cent a light seeded variety. This may be due, as will later appear, to the smaller size of the brown kernels. The seed used at Saskatoon has in some cases been cleaned down to half its original bulk. The seed is on the average considerably smaller than that of Rosen grown at the same station, though showing a much greater variability. Rosen is a variety developed at the Michigan Agricultural Experiment Station by selection from a sample from Russia. The Dakold has a darker green, narrower leaf than Rosen and is earlier. Dakold has shown at Saskatoon a very marked and consistent advantage over Rosen in winter hardiness. In comparable adjacent plots Rosen survived 16 per cent and Dakold 88 per cent. The yield of Dakold has averaged higher at Saskatoon than that of Rosen, but on plots where the winter survival of this variety has been equal to that of Dakold, it has usually excelled it in yield.

RYE BREEDING AT SASKATOON

The work at Saskatoon has been carried on with a double purpose:

(1) The improvement of the Dakold variety as a crop for Saskatchewan conditions.

(2) The study of the inheritance of characters in rye.

EXPERIMENTAL METHOD

Inbreeding after selection was decided upon as the method to follow. About two hundred plants of Dakold were selfed in 1925, usually two heads of a plant being enclosed in the glassine bags used. Considerable damage was done to these bags by rain and wind but plants were selected in which the bags had remained intact.

Further selfing was carried on in 1926 and 1927. Parchment bags were used in the latter year and they were found much more satisfactory than the glassine bags. In 1926 the plants of each line were seeded in rows twelve inches apart with four inches between each plant in the row. In 1927 the plants were spaced one foot apart each way. This planting

plan is very much superior to the other, where it is necessary to observe the characteristics of a plant, both for ease of observation and to give each plant an equal opportunity. In 1927 plots were grown side by side of the progeny of 1925 plants:

(a) Selfed in 1925, selfed in 1926 (from various plants in the line).
(b) Selfed in 1925, open in 1926 "
(c) Open in 1925, selfed in 1926 "
(d) Open in 1925, open in 1926 "
(e) Checks of Dakold from isolated multiplying fields.

Notes were taken on various characters in 1926 and 1927 and a study of the inheritance of some of these characters was made.

Inheritance of Fertility in Dakold Rye

In any field of rye the great majority of heads do not set a seed in every flower. Ulrich (1902) (*14*), gave the fertility of rye of various varieties as follows:

VARIETY	PERCENTAGE SEED-SETTING
Petkuser	80
Probsteier	59
Schlanstedter	78

It is worthy of note that the two high varieties, Petkuser and Schlanstedter, are the result of many years of selection. There does not appear to be any record of selection on Probsteier before 1902.

B. D. Leith (*8*), reports from Wisconsin on the same subject:

VARIETY	PERCENTAGE SEED-SETTING		
	1922	1923	1924
Wis. Ped. 2	69.4	65.4	64.15
Rosen	62.75	76.0	

Wisconsin Pedigree "2" is a strain selected from Schlanstedter. The original seed of Rosen was procured from Russia.

At Saskatoon our counts show:—

VARIETY	Percentage Seed-setting				
	FIELD		NURSERY		
	1926	1927	1925	1926	1927
Dakold	63.1	60.7	76.8	76.2	73.0

It appears evident that the better cultural and space conditions in the nursery make for higher seed setting than under crowded field conditions.

It is not safe to conclude that all the above figures are exactly comparable as methods of calculation may vary.

Fertility an Inherited Character

Rye is highly self-sterile; consequently, almost every seed on a plant is produced by the action of pollen from some other plant. The cloud of pollen blowing over the field is a mixture from plants which later show varying degrees of fertility. When the seeds are developed the heads of some plants are uniform for high seed-setting and the heads of others are uniform for low-setting. Different heads of the same plant show a high degree of uniformity in seed-setting percentage.

Seed-setting for three heads from each of eight plants was counted and the percentage fertility calculated. The probable error of the mean fertility of each plant was 2.65 per cent. High and low fertility plants varied by as much as nine times the probable error of the difference.

In 1926 several heads were harvested from each plant in a number of selected lines. Each line was the progeny of a single plant either open or self-pollinated. A count was made of the total number of flowers per head and the number of flowers per head producing a seed.

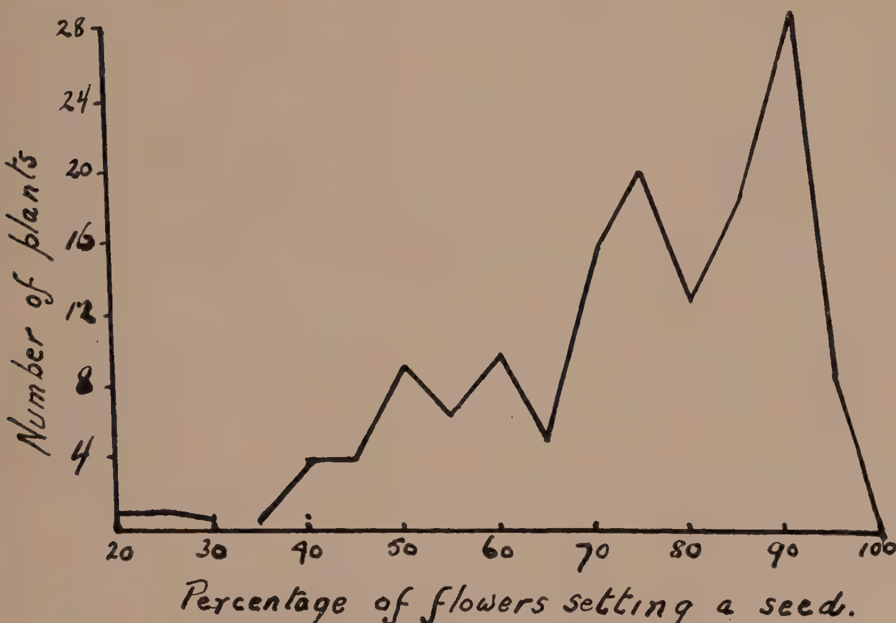

Figure 1. Fertility, 1926, of open pollinated plants.

A curve is shown illustrating the percentage seed-setting of 147 plants of open pollinated lines. This figure shows a great departure from the normal frequency curve. The plants may be divided into groups of high and low fertility. Some lines in 1926 showed a high degree of uniformity for high fertility, others showed a high degree of uniformity for low fertility.

In 1927 data were taken on many rows from self-fertilized and open fertilized seed of the same line. As it was desirable to take fertility percentage on as large a number of plants as possible in a large number of lines and as the differences between high and low fertility plants were so conspicious, the method was adopted of grading the plants into ten classes by inspection just before maturity.

Plants approximating 100 per cent fertility were placed in class 10 and others accordingly. While this system is slightly less accurate than making a careful count of the fertile flowers on each head, it enables a large number of plants to be graded by a single person and averages from these should be reasonably accurate. Twenty-five heads were graded for fertility percentage both by inspection and count. The correlation between the results arrived at by the two methods was .886 ± .029.

TABLE 2.—*Classification according to fertility.*

Line	Fertility % in mother plant 1925	Fertility % in mother plant 1926	Fertility 1927 of plants from heads selfed 1926: 10	20	30	40	50	60	70	80	90	100	%	Fertility 1927 of plants from heads open 1926: 10	20	30	40	50	60	70	80	90	100	
Homozygous high fertility group.																								
69 S–2	86.2	92.8						1	2	1	2				1			1	1	2	1	4	2	
179 S–1	76.4	81.9				1		1	1	4	6							1	2	5	8	6	2	
179 S–7	76.4	90.3						1	4	15	10							1	1	5	10	14	5	
184 S–5	53.0	85.3					1		3	3	9					1	1		1	4	8	8		
184 S–14	53.0	88.9							1	1	3							1		7	8	7	1	
342 S–2	65.2	90.0							2	3	1				1					2	5	2	1	
342 S–4	65.2	91.7			1	2		2	5	5	3									1	7	9		
357 S–2	48.2	91.2						1		2	1									2	1	7	2	
357 S–5	48.2	97.5						1	1	3	1								2	2	2	6		
426 S–4	70.0	96.7			1	1	1	1	1	3	2							1	2	2	6	15		
430 S–1	82.6	95.2						1											3	2	1	5	2	
440 S–1	90.0	93.2							1		1									2	2	5	2	
480 S–5	85.4	97.0						1	2	3	2	1					1		2		6	3		
Av.=	69.2	91.7			2	4	2	10	23	43	41	1	Av. 77.5		2	1	2	5	14	36	65	91	17	A 80
Heterozygous group.			10	20	30	40	50	60	70	80	90	100	%	10	20	30	40	50	60	70	80	90	100	
227 S–1	71.0	74.2				1	1	1	1									1	4	6	9	2	2	
277 S–4	71.0	75.8		1		1	3	2	9	14	5						2	1	1	2	4	6	1	
184 S–17	53.0	78.8		1	2	3		3	3	3	4				1	1	2	2	3	5	3	6		
342 S–1	65.2	91.1		1		1	3	6	3	4							1	2	2	6	7	3		
304 S–1	54.8	91.0		1			1	3	8	5	2					1		2	3	6	2	3		
39 S–13	50.0	71.5	4	1	2	4	1	4	6	7					2	5	3	2	3	8	10			
83 S–2	85.1	86.6			1	1		2	2	3					1		1	3	2	5	6	7		
85 S–1	75.0	86.8	1				1	1	1					1		1		1		4	2	3		
85 S–2	75.0	73.0		1	1				1	3	1					1	2	1	2	3	2			
135 S–1	75.0	84.1							2	2		1				1		1	1	3	4	2		
135 S–2	75.0	91.4	1			1	1	1	1	4					1			1	2	8	10	3		
245 S–2	46.8	80.0		1	1	1		1		1	1					3				3	4	3		
345 S–1	29.1	91.7						2			1					2	1	2	2	2	1	3		
468 S–3	31.4	81.8				2	1			1						1		1			4	3	2	
Av.=	55.8	82.7	6	7	7	15	12	26	37	47	14	1	Av. 62.7	1	5	16	12	20	25	61	68	44	5	6
Homozygous low fertility group.			10	20	30	40	50	60	70	80	90	100	%	10	20	30	40	50	60	70	80	90	100	
245 S–3	46.8	64.1			1		2	1							1	2	3	1	3	2				
355 S–1	41.6	83.3	2	2	2	3									1	2	3	1	1	3	1			
425 S–3	47.1	71.8				2	2	2							1	7	3	3	1	7				
Av.=	45.2	73.1	2	2	3	5	4	3					Av.=38.4		3	11	9	5	5	12	1	Av.=48.2		

In the data presented, the lines have been divided into three classes, homozygous high fertility, homozygous low fertility and heterozygous. There appears to be excellent ground for the supposition of a single factor difference between high and low fertility. No lines have been omitted from the table except where there was evidence of some outside influence at work.

No conclusions can be drawn from the table with regard to the proportion of high, low and heterozygous plants. This is due to the fact that the experiment was carried on partly with the purely practical aim of securing improved strains of rye; consequently, most of the low fertility plants have been eliminated by selection. For this reason also the fertility

of the parent plant cannot be taken as exactly typical of its class, the plants giving the highest fertility having been selected.

Curves are presented illustrating the three groups in plants from seed produced by self-pollination and open-pollination of the same plant. Some points brought out by the table and curves may be stated. Lines uniform

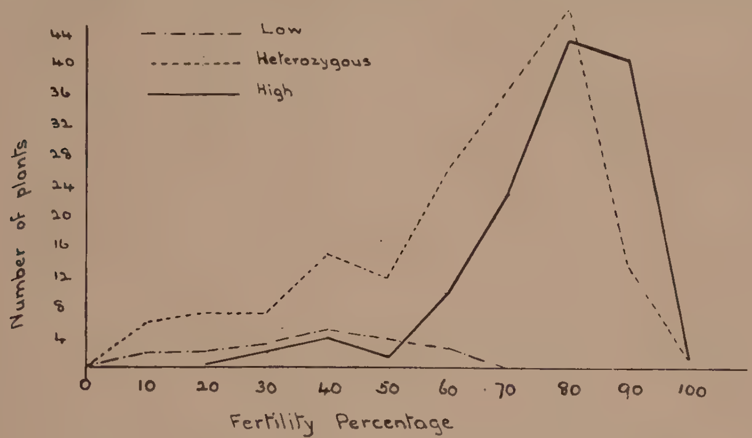

FIGURE 2. Fertility in 1927 of plants from heads selfed in 1926.

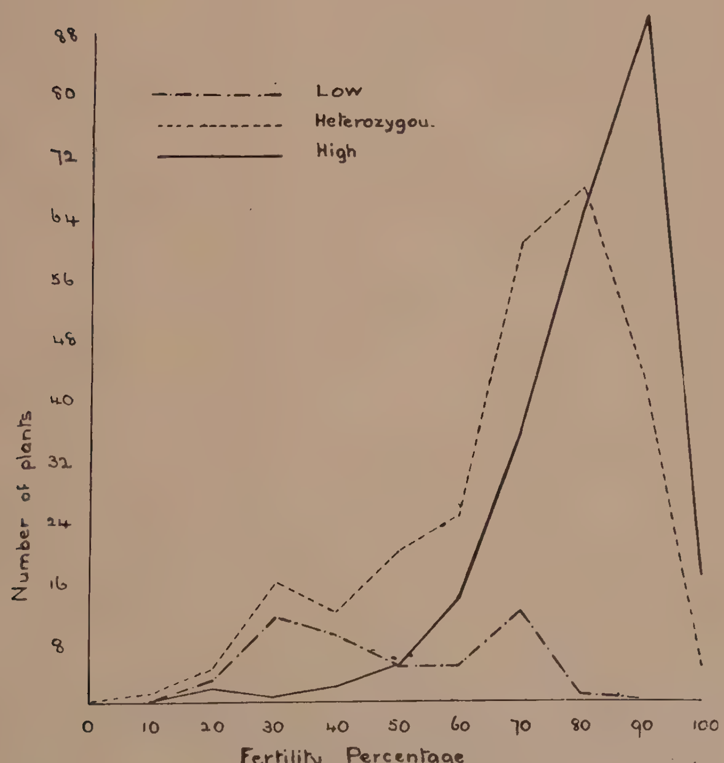

FIGURE 3. Fertility in 1927 of plants from heads open fertilized in 1926.

for high fertility are always from plants of high fertility. The seeds from open-pollinated heads give plants just as fertile as those from heads self-pollinated. Some of these plants must be the offspring of pollen from low fertility plants. Low fertility plants are almost totally absent from these lines. This would appear to indicate a dominance of high fertility over low.

Some lines are uniform for low fertility when grown from seed produced by self-pollination. These lines are from plants having a rather low average fertility in 1926. The plants grown in 1927 from heads open fertilized in 1926 show in each of the three lines illustrated a bi-modal curve. This is apparently due to many of the plants having been fertilized by dominant high fertility pollen.

Another group of lines has been described as the "heterozygous group". The plants in these lines show a wide range of fertility. The curves in both selfed and open sections are bi-modal. This is to be expected. A seed Hh would give rise to ovules H and h, and pollen H and h. Self-pollinated, such a plant would produce seeds:

H H 2 H h h h

If H is dominant to h one would expect about one-fourth of the plants to fall within the lower division of the bi-modal curve. Such is the case. Dividing the plants in the 50 per cent fertility class which appears to be the separating line, we get 131 high to 41 low. The departure from a 3:1 ratio is so small that it would be expected in more than half of a number of trials. No ratio can be expected in the plants produced by open fertilization. The character of the pollen parent would vary with location and the proportion of high and low fertility plants present.

Given a single factor difference between high and low fertility plants the parentage of the plants of known constitution in 1926 may be expressed by a table.

TABLE 3.—*Inheritance of fertility of selfed plants.*

Constitution 1926	1925
Homozygous high fertility (HH)	HH or Hh
Heterozygous (Hh)	Hh
Homozygous low fertility (hh)	Hh or hh

The fertility of the parent plants in 1925 as shown in Table 2 agrees very well with this finding. From the point of view of the practical rye-breeder this point is worthy of notice. Homozygous plants when selfed can beget only homozygous plants. Heterozygous plants will produce high, heterozygous and low in a 1:2:1 ratio. Each year the proportion of heterozygous plants will diminish. Plants homozygous for low fertility may be easily detected by the very low fertility of the open fertilized heads. If such plants are discarded at harvest time a population practically homozygous for high fertility will be secured in a few years.

Theory of Inheritance of Fertility in Rye

Jost (*6*) found self-sterility to be due to a lack of stimulation of pollen tube growth. East (*4*) in his studies on *Nicotiana* found this lack of stimulation to occur when some factor was present in both the pollen and the receptive organs of the plant. The question of fertility or sterility depended upon both the constitution of the pollen and the constitution of the receptive stigma.

In these rye plants the group described as "homozygous low fertility" shows low fertility when open fertilized. The amount of pollen blowing about the field is ample to fertilize every flower many times over and yet in these plants a large and uniform proportion of the flowers fail to set a seed. If each flower is such that pollen of some particular constitution is stimulated the fertility will be consistently low only if the required type of pollen is very scarce. There would therefore seem to be some question as to whether inheritance in these strains of rye is governed by the same conditions as those found by East.

The genetic constitution of the pollen may play a part in deciding the percentage of flowers which set seeds, but the data presented indicate no such action. Table 4 illustrates the inheritance of fertility if it depends wholly upon the genetic constitution of the plant on which the seeds are formed.

Table 4.—*Inheritance of fertility of plants selfed* 1926.

Constitution of parent plant 1925	Constitution of stigma 1926	Constitution of offspring 1926	Fertility % 1927
Homozygous low hh	hh	hh hh	Low Low
Heterozygous (Hh)	Hh	2Hh HH	High if H dominant
Homozygous high fertility HH	HH	HH	High
Open fertilized in 1926.			
Homozygous low (hh)	hh	hh Hh	Low High if H dominant
Heterozygous (Hh)	Hh	hh 2HH HH	Low High if H dominant
Homozygous high fertility (HH)	HH	Hh HH	High if H dominant

A condition in which a proportion of the ovules are abortive would also fit the results fairly well.

The precise manner in which inheritance of high or low fertility takes place will require further investigation. Jost was able to observe the differing speed of pollen-tube growth due to self-pollination and open-pollination. If such variations occur due to high and low fertility factors, they could be observed by the cytologist.

That there are high and low fertility strains cannot be doubted. A yield test was conducted in 1927 in which 24 strains from lines selfed in 1925 and three lines open in 1925 were tested against bulk Dakold. Three strains slightly exceeded Dakold in yield while some of the others yielded very much less. The data taken have not permitted the classification of all the strains as high, low and heterozygous in regard to fertility. The data do, however, indicate the highest yielding strain as one homozygous for high fertility and the two lowest yielding strains as homozygous for low fertility. Some of the differences are many times the probable error.

TABLE 5.—*Yield test of strains* 1927.

Strain	Av. Yield in grams	Diff. in yield from Dakold exceeds PED.
86 S	289 ± 13.90	1.72 times
Dakold	257 ± 12.36	
355 S	192 ± 9.24	4.1 times
245 S	180 ± 8.66	5.0 times
425 S	158 ± 7.59	6.8 times

The material used in this yield test had been open fertilized the previous year. The seed therefore in many cases was heterozygous for fertility and might be expected to vary less from the average than seed from an isolated breeding field where none but homozygous high fertility plants would be producing pollen.

There seems an excellent prospect of increasing the yield of the rye crop by the use of seed homozygous for high fertility.

Kernel Colour

It has been mentioned that in the Dakold rye in use at Saskatoon light-coloured seed now predominates. Dakold is described in U. S. D. A. bulletin No. 1358 (*9*) as possessing "small dark-coloured kernels." Evidence is conflicting as to the colour of the Dakold seed, originally received at Saskatoon, but it at least contained a considerable proportion of dark kernels. This seed has survived some hard winters; in 1925 a large proportion of even the Dakold was winter killed. Considerable care has been taken to prevent the mixture of varieties by cross-pollination. The fact that the variety is now so largely light coloured and yet continues to show a high degree of hardiness is worthy of notice. It is probable that there is no linkage between dark colour and hardiness.

F. W. Amend (*1*), in his statistical study of Flemish rye, found a high correlation between kernel colour and kernel quality. As no translation of this work into English is available, a lengthy quotation seems permissible: "The opinions regarding the value of kernel colour in rye varieties have in course of time had to undergo certain changes. Today people commonly incline to the opinion that the green colour is to be given the preference over yellow or even dark-brown, and so we see nowadays almost all important rye-breeders breed to green kernels (Petkus, Kloster Hadmersleben, Pirnaer Genossenschaft and others).

"The station in Couckelaere (Belgium) has, according to the statement of the director, attributed less importance to this factor, and a selection of the elite ears for green kernels has up to now never taken place. If nevertheless, the elite of 1915 is quite predominantly green-kernelled, this circumstance seems to indicate that the green-kernelled families surpass the yellow and brown. There is an unconscious selection for green kernels and consequently an intensification of this quality took place. Also the fact that the inclination to green colour in the old form of Flemish rye is far less as compared to the improved points to that.

"I found indeed only few ears with green kernels throughout; on the other hand many ears show a greater or less percentage of the kernels a more or less intense green colour with shading off from blue green, through gray-green, to yellow green hues. Also in the improved rye I found fairly frequently brown and brown-pointed kernel types (the brown colouring of the seed coat can vary from a deep black-brown to a clear dark-brown).

"According to the opinion of von Rumker the brown kernels and brown-pointed kernels in rye are to be regarded as faulty in that the yield of grain and straw and the winter-hardiness are lowered. He has further established that the darker and more uniformly the brown colour is spread over the kernel the more faulty is the development of the whole plant and the lower the yield. As the full brown kernel is hereditarily developed out of the brown pointed one, the latter also keeps a natural tendency to this crop-lessening fault which the rye-breeder must overcome.

"I have taken the different kernel colours, green, gold-brown and dark-brown types of the improved Flemish rye as a subject for further researches and have through comparison of the various colour-steps observed as follows:

KERNEL COLOR	WT. PER 100 KERNELS	VITREOUSNESS
Green	3.24 gms	95%
Gold-brown	3.25 gms	38%
Dark-brown	2.84 gms	69%

The comparative germination strength was as follows:

Green kernels	100
Gold-brown	97.4
Dark-brown	81

The different kernel colour does not depend upon the outer seed coat, which is always the same yellow-brown."

Amend's microscopic investigation of kernel colour showed:

(1) *Dark-brown colour:*

An extremely yellow-brown layer under which lies a quite strong red-brown coloured layer, the real pigment. The aleurone layer is gray with a shade of red.

(2) *Gold-brown colour:*

A thin almost colourless outer layer under which lies the real brown-yellow pigment. The aleurone is again gray.

(3) *Green colour:*

The real seed coat shows a thin yellowish and a thicker more brownish pigment, while the colour of the gluten cells seems to be perfectly blue.

He says, "The deeper reason for the various kernel colours lies, therefore, in the colour and development of the most important gluten layer; for this reason there, without doubt, exists a close relation between kernel colour and the intrinsic value of the kernel."

Counted samples of Dakold rye of different colors were weighed at Saskatoon:

Table 6.—*Weight of* 100 *kernels Dakold, Saskatoon*, 1927.

	grams	
Green kernels	2.74	.014
Yellow kernels	2.61	.014
Dark brown kernels	2.21	.014

The green, yellow and brown kernels of Dakold were microscopically examined and the findings agree with those of Amend. In the green rye there is a thick layer of dark blue cells.

It may be commented that the diminution of dark coloured kernels referred to by Amend, in the improved as compared to the original Flemish rye, is perhaps the result of selection for size which would, on these findings, bring about a gradual elimination of kernels of this colour, owing to their smaller average size. It is also evident that, where no care is taken in selection, the dark brown kernels might hold their own by producing as many kernels as any other colour while producing a lower yield by weight. The writer has been unable to examine von Rumker's evidence of the inferiority of the brown-kernelled plant.

In rye, as in wheat, the question of grain colour may have a commercial importance apart from its relation to the intrinsic value of the grain. Any increase in production of rye in Canada must seek an European market. There is, both among the German plant-breeders and among German farmers with whom the writer has spoken, a strong preference for green rye. According to Amend and von Rumker this preference has real economic importance. Germany is at present importing rye from America and though colour has not been an important factor in Canadian market prices in the past, any preference for green rye in Germany is likely to be reflected in prices here. It is, therefore, desirable that Canada should produce a green rye if this can be done without lowering the yield and increasing the danger of winter-killing. Whether a rigid selection for green kernels would lower winter hardiness by decreasing heterosis, can only be ascertained by experiment.

Green-seeded rye is dominant to yellow-seeded; von Rumker found a ratio of three green to one yellow in F_2. Many green seeds will thus be heterozygous, but if the selfed heads of a plant produce a number of seeds all of which are green, the plant is likely to be homozygous for that character.

Heterosis

Heterosis may be defined as the increased vigour often shown in the first generation of a cross. This increased vigour is assumed to arise from the

presence of many dominant growth factors in a heterozygous condition. For example, A may give vigorous plants when crossed with B or C and yet B when crossed with C may show no heterosis. It has seemed desirable to discover which strains give the maximum vigour when crossed. For this test the following planting plan has been devised.

Twenty-six strains were planted in single rows north and south, the seeds one foot apart in the row. The same twenty-six strains were planted in single rows east and west, a seed midway between each two seeds of the rows previously mentioned. The diagram illustrates a portion of the planting plan.

A	B	C	D
A	A	A	A
A	B	C	D
B	B	B	B
A	B	C	D
C	C	C	C
A	B	C	D
D	D	D	D

It is planned to cover with a parchment bag two heads from each of two adjacent plants. The experiment will be in duplicate as plants of any two lines will occur together at two points. Notes will be taken on fertility with a view to discovery of (1) individual lines which mate well, and (2) the sum of fertility in any line. If A when mated with the 25 other strains gives higher fertility than B when mated with the other 25 it may be considered a more desirable strain for use. If a group such as AB, AC and BC gives marked heterosis in the following generation. lines AB and C may be grouped for a yield test. The resemblance of the progeny of crossed lines to one or other of the selfed parent lines will give information on dominant and recessive characters.

Disease

The disease giving most trouble in rye is ergot. In this regard two statements made to the writer may be contrasted. Mr. J. F. Reid of Arcadia, near Yorkton, Saskatchewan, has been growing rye for several years. He says, "We are still growing rye, but the ergot is a very serious drawback. We would grow more but for ergot." Mr. Templin, a young man who recently came to Canada from a farm in West Prussia where rye is the leading grain crop, says "There is ergot in West Prussia. I was told about it at the Agricultural High School, but I have never seen any."

The climate of West Prussia may be less suited to the growth of ergot than that of Saskatchewan but there may be other reasons for the difference. Mr. Templin also says "no farmer in our district grew more than three successive crops from his own seed if he could possibly afford it. He bought new seed from the breeding station." Such a practice might greatly reduce ergot in Saskatchewan. The rye grown at the University of Saskatchewan is hand picked. The large ergot bodies are removed by the fanning mill but the small broken pieces have to be removed by hand picking. This seed is also usually a year old when sown and small pieces of ergot are likely to lose their vitality in that time. If farmers made a practice of purchasing a few bushels of

such seed each year and growing the crop on a field some distance from other rye and some distance from land occupied by rye in the previous year, ergot would probably cease to be a serious trouble. The permanent solution of the problem of ergot control is probably to be found in the selection or breeding of disease resistant varieties. Such work has been done in the case of flax wilt, stem rust, covered smut and other diseases.

Rotation

It may be remarked also that some of the farmers in eastern Saskatchewan, having very good success with rye the first year, proceeded to grow it continuously as they had previously grown wheat. In Prussia where rye is the leading grain crop the customary rotation is: sugar beets, barley, potatoes, rye. An occasional crop of lupines is sown for soil improvement but chemical manures are largely used for this purpose. It is inadvisable because of ergot to grow rye continuously and a rotation of fallow, wheat, cultivated crop, rye might be found more profitable.

There is a little difficulty in sowing a fall crop after a cultivated crop and a winter crop absolutely demands moisture in the soil. The moisture is likely to be most plentiful after fallow. On the other hand rye has a lower nitrogen requirement than wheat and the nitrogen content of the soil should be highest after fallow. If rye is not followed by fallow there is sure to be a considerable amount of rye in the succeeding crop as it shatters rather freely and the volunteer growth is winter hardy.

Winter Hardiness

Winter killing has been attributed to various causes. In Europe heaving of the soil was stated by my Prussian informants to be the chief cause. Alternate freezing and thawing in spring have been also considered important.

Studies of the winter killing of wheat in the drier areas of the United States give chief importance to other causes. Kiesselbach (*8*) says "Heaving of the soil and smothering by sleet or ice are only minor causes of infrequent occurrence in Nebraska. The prime causes for failure to survive the winter are (1) freezing to death by extreme cold and (2) dessication due to moisture shortage."

Though winter rye may serve a useful purpose in checking soil drifting in the drier areas, it should be appreciated that the conditions are not well suited to the crop. In July, 1920, a "Better Farming Congress" was held at Swift Current. Winter rye was advocated to check soil-drifting. In south-western Saskatchewan drought is a danger and the winters are usually open. About the same time a few farmers in the Yorkton area of east-central Saskatchewan commenced to grow winter rye for the purpose of meeting the invasion of Canada thistle and sow thistle. In that area precipitation is above the average for Saskatchewan, and the ground is usually covered with snow from November to March. The results may be compared from the statistics of the Saskatchewan Department of Agriculture (Annual reports, Saskatchewan Department of Agriculture, 1921-27).

TABLE 7.—*Comparison of acreage and yields of rye in two crop districts of Saskatchewan.*

	ACREAGE OF WINTER RYE South-western crop district (acres)	East-central crop district (acres)	YIELD OF WINTER RYE AND SPRING WHEAT S-W district rye	wheat	E-C district rye (bushels)	wheat
1920	46,909	8,733	13.3	9.9	13.8	15.0
1921	899,889	16,324	10.1	9.2	22.0	18.0
1922	223,671	33,156	13.18	18.75	24.41	21.25
1923	32,001	12,432	11.50	16.75	20.50	18.00
1924	19,562	24,208	6.1	6.8	20.15	10.10
1925	42,182	43,577	8.3	9.8	23.0	19.9
1926	57,020	68,250	7.7	8.8	23.6	19.5
		Average yield	10.02	11.43	21.07	17.39
Rye yield as percentage of wheat yield—Seven years' average			87.7	100.0	121.1	100.0

In south-western Saskatchewan spring wheat yielded more than rye in five out of seven years. In east-central Saskatchewan winter rye yielded more than spring wheat in six out of seven years. These differences are not necessarily entirely due to winter-killing, but that is likely to be an important contributory cause. The different purposes for which rye is grown may, of course, have contributed to these results. Rye grown in south-western Saskatchewan to control soil-drifting might be sown on poorer land than wheat in the same area. Farmers who grew rye to control sow thistle in east-central Saskatchewan may have been better farmers than those who did not. The difference in yield of rye for the two areas is, however, so large that only the necessity for checking soil-drifting would induce a farmer to grow rye in any district subject to drought and open winters. The farmers of east-central Saskatchewan who grew twenty-one bushels of rye to the acre while controlling the sow thistle, Canada thistle and wild oats must have found it a very profitable crop.

The degree of cold to which winter crops are exposed depends greatly upon the amount of snow covering. The superintendent of the Dominion Experimental Sub-station at Beaverlodge, Alberta, reports: "During the sub-zero air temperatures of November and December, the thermometer once reaching —40°F. in the latter month, the soil thermograph (3 inches below the soil surface) did not drop lower than 19°F, which it touched on December 28th. This goes to suggest why winter wheat, alfalfa, small fruits and other perennial crops are being successfully raised in the Peace River country. Undoubtedly it is largely owing to the protective influence of snow."

An enquiry has been made by the writer to discover if any correlation exists between soil thermograph readings at Saskatoon and winter-rye survival. In the winter of 1924-25 there was much winter killing of rye. Unfortunately the soil thermograph has not been in the same position all the time and except during the last three years there are few data as to the depth of snow covering.

TABLE 8.—*Soil temperature 3 inches below the surface at Saskatoon, Sask.*

Month	1924-5		1925-6		1926-7		1927-8	
	Minimum temp.	Snow covering	Minimum temp.	Snow covering	Minimum temp.	Snow covering	Minimum temp.	Snow covering
Oct.	34°		25°		36°		32°	
Nov.	26°		6°		30°	8 ins.	21°	12 ins.
Dec.	8°	3–4 ins.	1°	no snow	26°	13 ins.	14°	3 ins.
Jan.	8°		2.5°	trace	20°	12 ins.	9°	
Feb.	8°		3.5°	8 ins.	21°	16 ins.	5°	little snow
Mch.	14°		8.5°		26°	8 in. thawing	3°	no snow Mch. 4
Apl.	30°		23°		33°	no snow	17°	
May	33°		31°		37°	"		

The chief interest of this table lies in the extraordinarily high minimum temperatures during the winter 1926-27. That winter was cold but the snow was deep. The winter wheats tested at Saskatoon for the United States Department of Agriculture had a good covering and even Blackhull, a variety against which Kansas farmers have been warned because of its lack of hardiness, came through with a good stand.

The temperatures of the winter of 1927-28 are also worthy of note. The coldest weather occurred in November and December but the snow covering was good and soil temperature was high. A thaw came early in January which removed the snow and in spite of comparatively mild weather soil temperatures fell. Large areas of the university rye plots which have been bare of snow since January 4th, are winter killed while the volunteer rye, growing where the stubble of the previous year's crop held the snow, is uninjured.

EXPERIMENTS IN WINTER-HARDINESS

An attempt was made in 1926 to test different strains for hardiness. Pots and flats containing 648 rye plants were taken from the greenhouse on a mild day in November and covered with four feet of straw. On December 18th, the straw was removed with the exception of six inches. In January and February the plants were returned to the greenhouse. None survived. Two possible reasons for the killing of the entire first series of plants are:

(1) Low temperatures before plants were thoroughly hardened off. (According to Tisdal (*13*) the hardening off requires at least a week).

(2) Drying out of the pots resulting in a lowering of the vitality of the plants (the pots were surrounded by dry straw and became very dry before the soil in them was frozen).

In 1927 a similar experiment was planned but the rye was seeded in pots in September, and placed directly outdoors. There was early a heavy covering of snow over the pots (10 inches). On November 22nd, the pots were brought into the greenhouse. Every plant survived. Owing to long continued severe weather it was impossible to test the hardiness of these plants until they had reached a stage which was not at all repre-

sentative of field conditions. On two occasions 12 pots were exposed but no significant differences were obtained. Where survival depends to such a large extent upon snow covering, it is difficult to get any significant result from a pot test unless all snow is carefully removed. The plants would then require exposure only to comparatively mild temperatures. The conclusion of the writer is that hardiness tests with plants in pots are only practical with artificial refrigeration.

It was observed in 1927, when the stands of winter rye on most plots showed an almost complete survival, that on one block where a ridge of soil ran across several plots, the different varieties showed a winter killed strip of varying width. The wind had swept the protective snow covering from the ridge. Rosen was killed to the extent of 75 per cent of the plot. Dakold showed only marked thinning at the crown of the ridge. Wisconsin was intermediate. This corresponds with the known winter-hardiness of these varieties.

This leads to the suggestion of a field winter hardiness test conducted on a plot having the contour of a graded road. The strains would be sown in single rows crossways of the grade and replicated at least six times. The experiment should be made in an exposed situation.

Summary

1. Self-fertile lines from Dakold rye averaged as high in viability and winter hardiness as check material.
2. Fertility was higher in the favorable environment of the nursery than in the field.
3. Heads of any given plant are highly uniform in fertility.
4. Plants may be divided into three groups:
   (a) homozygous for high fertility.
   (b) homozygous for low fertility.
   (c) heterozygous.
5. High fertility is apparently dominant.
6. The differences in fertility are reflected in differences in yield.
7. Brown kernels are smaller than yellow and green.
8. A method is outlined for testing heterosis in controlled crosses.
9. Ergot is largely controllable by seed selection but disease resistant varieties are desirable.
10. Winter killing is largely due to lack of snow covering.
11. A new method is suggested for testing winter hardiness.

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BOOK REVIEW

Green Manuring: Principles and Practice. By Adrian J. J. Pieters. (Pp. 356. John Wiley & Sons, New York. Price $4.50.)

Green manuring, or the turning under of green crops, is today generally recognized as one of the most effective and economical practices for the improvement, chemically and physically, of the soil. As a means of furnishing humus-forming material—the storehouse of nitrogen and an essential and important constituent of all fertile loams—this "green stuff" has only one rival, barnyard manure, of which few farmers have sufficient to keep all their arable land to its highest productive power. More than thirty years ago the Experimental Farms system conducted a series of eminently practical field tests, accompanied by analytical work, which showed satisfactorily and conclusively that greatly increased crop yields, in potatoes, grain and corn, followed the ploughing under of a crop of clover and this beneficial effect was apparent for a number of years.

The book here reviewed may be heartily commended to the agricultural student who is desirous of a text book discussing this important matter in all its phases. The author, Dr. Pieters, of the Bureau of Plant Industry, U.S. Department of Agriculture, is evidently conversant with all that is known on the subject and he has thoroughly traversed the whole field in the compilation of this treatise. It is an excellent and valuable contribution to agricultural literature, and our thanks are due the author for bringing together in orderly manner and from widely scattered sources such a mass of useful information on the use of green crops for fertilizing purposes.

Its fourteen chapters present this fund of information in a well-arranged way and many tables of data, field and analytical, support the clear statements of the writer. At the close of each chapter there is a summary which will be found especially useful to the student. The illustrations are apt and well reproduced. It is a book which we should like to see on the curriculum of our agricultural colleges and it can also be recommended to the notice of every reading farmer.

F.T.S.

THE INFLUENCE OF THE MOISTURE CONTENT OF THE SOIL ON THE TEXTURE AND WEIGHT OF WHEAT GRAINS.

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[Received for publication April 12, 1928.]

The different physical and chemical properties of wheat grains have an important connection with bread-making qualities. Much work has been done in the past, particularly in America, on this problem, which has had for its object the finding of a connection between the different physical and chemical properties and also between the external appearance of the wheat grains and the milling and baking properties. On the other hand investigators have looked for some measure of quality in wheats in order to find characteristics to determine their respective values for milling and baking. From this point of view they have tried to establish certain correlations between the different qualities of wheat grain.

For example Mangels and Sanderson (*1*) have established a positive correlation between the quantity of protein in the grains and the percentage of hard vitreous grains. This correlation has varied from year to year.

J. H. Shollenberger and D. A. Coleman (*2*), in analyzing samples of spring and winter wheat from the point of view of texture and weight per unit volume have found that grains of intermediate texture have the greatest weight per measured bushel. Those of farinaceous texture have the smallest weight per measured bushel, and those of vitreous texture have an intermediate weight. On the other hand they found no correlation between the weight of 1,000 grains of wheat and the texture, and they say: "It might be expected that the weight per 1,000 kernels would have a consistent relation to test weight per bushel but this is not the case."

The wheat samples which they analyzed were of different varieties collected from different places. They found indeed a positive correlation between the texture of the wheat grains and the percentage of protein, grains of vitreous texture having the greatest quantity of protein, 10.70 to 14.39 per cent, those of intermediate texture 8.18 to 13.02 per cent, and those of farinaceous texture 7.49 to 9.86 per cent. The flour produced from grain of vitreous texture also had the greatest protein, gliadin, dry gluten and moist gluten content, a group of qualities of the greatest importance in bread--making.

The fact that they found no correlation between the weight per unit volume and the weight of 1000 grains is quite understandable if we remember the fact that the samples of wheat analyzed originated in different places, and were cultivated under quite different conditions.

R. Newton, W. H. Cook and J. G. Malloch (*3*), studying the different properties of wheat grains and particularly the connection between the hardness (resistence to crushing) and the kernel dimensions and percentage of protein, have found no general correlation, but they have found a good relationship between the resistance to crushing and the texture and per-

centage of protein for wheat grains taken from the same sample. In this connection they say: "It must be concluded that a relation between hardness and protein content exists only within a given sample, in which other factors of difference are ruled out. The same conclusion must be reached in regard to vitreousness and protein content at least in so far as a linear relationship is concerned. The factors which disturb the relationship do not seem to depend upon inherent differences between varieties, since there is no greater consistency observable in a series of samples of one variety grown under different conditions than between samples of different varieties. Apparently the conditions of growth, modifying the development of the kernel and the manner in which various constituents are laid down, influence kernel texture, hardness and protein content somewhat independently."

Various experiments that I have made at the Agricultural Academy of Cluj (Roumania) under different cultural systems applied to "Banat" wheat show that these assumptions are justified. The influence of different vegetational factors has a marked bearing on the formation of the wheat grains.

Experiments on wheat seed with different distances between the rows show that the weight per unit volume decreases, whereas the weight of 1,000 grains increases as the distance between the rows becomes greater.

In another series of experiments it was found that the weight per unit volume and that of 1,000 grains are influenced if one changes the amount of seed sown per unit area, as shown in Table 1.

TABLE 1.—*The variation of the weight per hectolitre and that of 1,000 grains under the influence of different amounts of seed.*

No. of seeds per sq. metre	64	95	165	227	288	371
Weight per hectolitre in Kgs.	76.08	77.28	76.39	77.41	77.71	77.98
Wt. of 1,000 grains in grams	52.97	52.60	50.42	49.75	49.35	49.92

In both cases the variable factor was space, which was varied by increasing the quantity of seed. From the results of this experiment it is evident that the weight per unit volume of wheat grains varies inversely as the vegetation space factor and that the weight of 1,000 grains varied in the same sense as the vegetation space factor, but in the opposite sense to the weight per unit volume.

Another vegetation factor which can greatly influence the formation of wheat grains is the water factor, which varies widely in different regions, and can produce different development in grains of the same variety. The way in which this factor varies during the vegetation period of the plant is also a decisive factor. In connection with this fact Kezer (*4*) in irrigating wheat during different stages of its growth (tillering, jointing, heading, blossoming and filling) found that the protein production was great when the wheat had been watered during the whole of its period of growth, but

that the best quality of wheat and of protein was produced when the irrigation was applied during the heading and blossoming.

D. W. Robertson and A. Kezer (*5*), in studying the same problem, found that if water is applied during the jointing stage the yield of grain and straw is increased, but not the quality of grain, nor the weight per unit volume nor the weight of 1,000 grains. If water is given during the heading period it causes a decrease in the quantity of grain and straw, but the quality of grain is improved. Irrigation applied during the time of blossoming and filling has only a slight influence on the quantity of straw and grain but it increases slightly the volumetric weight and the weight of 1,000 grains. Finally, irrigation applied during germination and tillering has a greater influence on the yield of straw than on that of grain but it improved the grain quality.

The author (*6, 7*), in studying the action of water given in different quantities during the period of growth on the development of spring wheat, found that this factor has a great influence on the development of the plant in general and especially on the formation of grain. Certain data, which have been collected when the yields obtained in pot experiments were examined, also show, in some degree, that the quality of wheat grains can be affected by conditions of growth. The wheat used in these experiments was "Arnaut" (*Tr. durum hordeiforme*) and "Ulca" (*Tr. vulgare lutescens*) both well known in the dry regions of Bessarabia. Both varieties were grown in pots filled with earth prepared in a uniform way and treated with an increasing quantity of water. After the harvest, among other examinations, the degree of hardness was determined with the farination apparatus and also the weight of 1,000 grains. With this apparatus (Farinometer, Körner-schnittapparat, Kornprüfer, Kornschneider von Heinsdorf) (*8*) 50 grains of wheat were cut in a transversal plane roughly in half. The sections of the grains were examined visually, were counted, and then divided into four groups according to their texture. Those which were completely vitreous were labelled 1, those which were three-quarters vitreous were labelled 0.75, those which were half vitreous as 0.50, those only a quarter vitreous as 0.25 and those which were completely farinaceous as 0.

To find means between the limits of probable error, this operation was repeated eight times. Four hundred grains were cut in this way in each case. The results are given in Table 2.

From these figures it is seen that the grain texture of both wheats has been greatly affected by the amount of water contained in the soil. At the same time the influence was different for the two varieties of wheat. In the case of the "Arnaut" wheat characterized by a high, long grain, in colour yellow like wax, increases in the amount of water in the soil has produced a great increase in hardness up to a certain limit (45 per cent), beyond which the hardness diminished again. With the "Ulca" wheat the reverse was the case: increase in moisture content of the soil produced a continuous decrease in degree of hardness. The weight of 1,000 grains for both kinds of wheat increased steadily in direct proportion to the increase in soil moisture. In comparing the qualities of the two wheats it was

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TABLE 2.—*The variation of the degree of hardness and of the weight of 1,000 grains under the influence of water content in soil.*

Water content in soil (% of the water holding capacity)		Degree of hardness 1	0.75	0.50	0.25	0.0	Total % of hard grains	Weight of 1000 grains gr.
		Arnaut (Tr. durum hordeiforme)						
15	Number of grains	90.50	4.25	0.25	--	--	98.81	41.3
30		95.75	4.25	--	--	--	98.93	46.4
45		97.00	3.00	--	--	--	99.25	47.2
60		86.25	4.50	2.75	1.75	4.75	91.43	48.2
		Ulca (Tr. vulgare lutescens)						
15	Number of grains	2.75	34.00	40.50	21.25	1.50	53.81	36.3
30		1.00	34.75	38.50	22.50	3.25	51.93	38.5
45		1.34	26.67	43.00	26.34	2.34	49.58	42.6
60		0.50	30.75	37.50	27.50	3.75	49.18	50.8

found that the quality of grain for "Ulca" wheat was more strongly influenced than that of the "Arnaut" wheat by varying moisture contents, as can be seen also in Figure 1.

In another series of experiments with "Ulca" wheat, water was given in varying quantities during the different stages of growth shown in Table 3.

TABLE 3.—*The variation of water content (% of the water holding capacity) of soil during the different stages of growth.*

Groups	STAGES OF GROWTH I Sowing to tillering	II Tillering to jointing	III Pointing to blossoming	IV Blossoming to filling
1	45	20	20	20
2	45	45	20	20
3	45	45	45	20

After analyses with the "farination apparatus" the grain hardness varied as is indicated by the figures in Table 4.

TABLE 4.—*The variation of the degree of hardness of grains of "Ulca" wheat under the influence of variation of water content of the soil during the different stages of growth.*

Groups	Water content of soil at different stages of growth (% of the water holding capacity) I	II	III	IV		Degrees of hardness 1	0.75	0.50	0.25	0.0	Total % of hard grains
1	45	20	20	20	Number of grains	0.25	33.50	27.50	30.25	8.50	46.68
2	45	45	20	20		0.25	3.5	23.25	63.00	10.00	30.25
3	45	45	45	20		0.0	3.5	11.80	72.70	12.00	26.06

From these data it is seen that in the first case, when water was given at the rate of 45 per cent only in the first period of growth the percentage of vitreous grains was at its greatest. Further, if the greater quantity of water (45 per cent) is given also in the following periods of growth the degree of hardness decreases regularly.

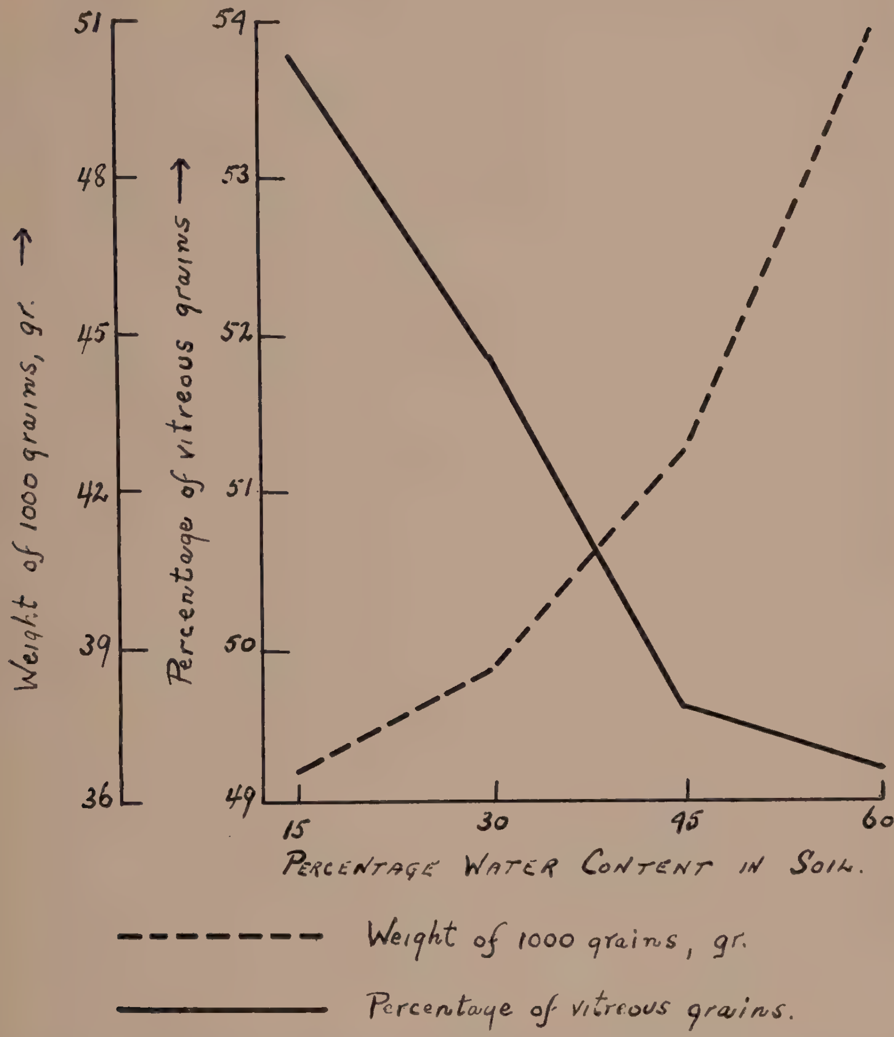

FIGURE 1. Variation in the texture and weight of "Ulca" wheat grains under the influence of quantities of water varying during the different stages of growth.

The way in which the distribution of a hundred grains between the different degrees of hardness occurred, was different in the three cases on account of the difference in the amounts of water given. This can be best seen in Figure 2, in which are drawn curves for variations of texture of wheat grains, in the first case when water was given at 45 per cent only in the first stage of growth, and the third case when the same quantity of water was given in the first three stages. This fact also corresponds to the way in which the process occurs in nature in the dry parts of Bessarabia. The soil is in a favourable condition of moisture for the growth of wheat only at the beginning of spring, because later the dry season sets in and consequently wheat harvested in this region has generally a high degree

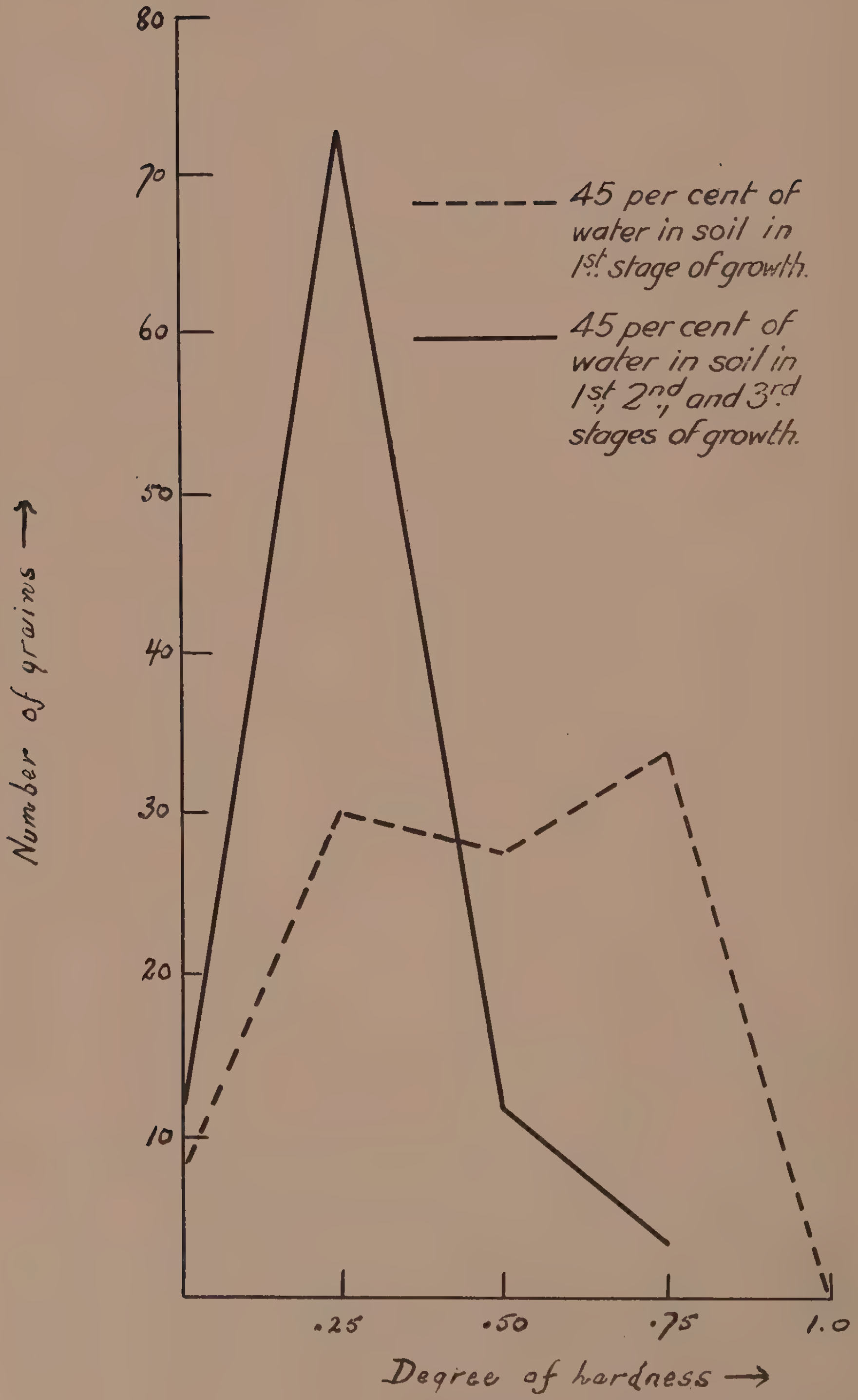

Figure 2. The variation in the texture of the grain of spring wheat "Ulca" with the manner of distribution of water during the different stages of growth.

of hardness. "Ulca" wheat sown in the humid regions has a grain of less vitreous texture.

In another experiment the percentage of water in three series of pots was varied in the opposite sense from the previous case, as can be seen from Table 5.

TABLE 5.—*The variation of water content (% of the water holding capacity) of soil during the different stages of growth.*

Groups	STAGES OF GROWTH I Seeding to tillering	II Tillering to jointing	III Jointing to blossoming	IV Blossoming to filling
1	20	45	45	45
2	20	20	45	45
3	20	20	20	45

The results from these experiments are given in Table 6. The variation in amount of water during the stages of growth as is seen from Table 5 is in fact contrary to the natural conditions in which the wheat grows in Bessarabia.

TABLE 6.—*The variation of the degree of hardness of grains of "Ulca" wheat under the influence of variation of water content of the soil during the different stages of growth.*

Groups	Water content of at different stages of growth (% of the water holding capacity) I	II	III	IV	Number of grains — Degrees of hardness 1	0.75	0.50	0.25	0.0	Total % of hard grains
1	20	45	45	45	--	7.50	19.00	57.50	16.00	29.37
2	20	20	45	45	--	5.00	21.00	63.00	11.00	30.00
3	20	20	20	45	0.25	7.50	33.70	52.50	4.25	36.25

But from the data given in Table 6, it is seen that the results were the same as in the earlier experiment. Although the favourable amount of water (45 per cent) was given after the smaller percentage, the plants which developed during a longer period of drought produced grains of a greater degree of hardness.

From the figures in the table it is seen that parallel with the decrease in the wet period and the increase of the dry period the percentage of vitreous grains in the yield increased.

From these experiments the following observations were made:—

1. The physical properties of wheat grains vary greatly with differences in cultural conditions, but this variation takes place within the limits imposed by the characteristics of the different varieties.

2. For the same variety of "Banat" wheat, under uniform conditions of growth, if the space factor of vegetation becomes smaller, through an increase in the amount of seed per unit area, the weight per unit volume of the grains increases, and the weight of 1,000 grains diminishes.

3. For "Ulca" and "Arnaut" spring wheats the grain texture and the weight of 1,000 grains varies as a function of the moisture content of the

soil. The hardness of the grains of Arnaut wheat varies very slightly, but in the same sense, up to a certain limit, with the variation in moisture content of the soil. On the contrary with Ulca wheat the grain hardness varies in the opposite sense as the moisture content of the soil. In both wheats, the weight of 1,000 grains varied in the same sense as the moisture content of the soil.

4. For "Ulca" wheat the degree of hardness of the grain varied in the same sense as the extension of the period of drought during the growth of the plant. The vitreous texture of the grain was more strongly influenced when the drought took place during the last stage of growth.

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BOOK REVIEW

College Chemistry. By Neil E. Gordon. (World Book Company, Yonkers-on-Hudson, N.Y. and Chicago, 1928.)

Two text-books by the same author and publisher have been previously reviewed (Vols. VI, p. 431, VIII p. 391)—one intended for college students who have had no previous course in chemistry, the other for high school students. The present work is for college students who have had High School chemistry and is designed to supplement, not to review, previous training in general chemistry. The matter is arranged in two parts, Non-metals and Metals, divided, respectively, into seven and eight units of two to five sections. Each unit covers a periodic or an analytical family of elements or a broad theoretical topic. Directions for experiments, including a number in qualitative analysis, are interspersed through the text.

Besides the admirable pedagogic arrangement indicated by the above outline, the most striking feature of the book is the extent to which modern theories of atomic structure are introduced and applied. It is obviously a thoroughly modern text.

J.F.S.

THE DOMINION GOVERNMENT ILLUSTRATION STATIONS IN BRITISH COLUMBIA*

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In the province of British Columbia twelve Dominion Government Illustration Stations are in operation, supervised from the Experimental Farm at Agassiz. Seven stations are in central British Columbia along the line of the Canadian National Railway, serving a stretch of territory 400 miles wide. The stations are located at McBride, Salmon Valley and Prince George on the Upper Fraser, Vanderhoof in the Nechako Valley, Francois Lake in the Francois and Ootsa Lakes district and Telkwa and Smithers in the Bulkley Valley. Three stations are in operation on Vancouver Island situated at Comox, Courtenay and Alberni. Two are in the southern interior at Kamloops and Armstrong.

Three new illustration stations were selected in the fall of 1927. One is located at Fernie in the East Kootenay district, one at Salmon Arm and the other near Duncan on Vancouver Island.

Object of Work

The primary purpose of the Illustration Station is to illustrate or demonstrate the methods and value of good farming. The Illustration Station provides a means of contact between the Experimental Farm and the farmer and thus supplies a very useful and necessary form of extension service for the Experimental Farms system.

The Illustration Station is located on a privately owned farm. The effectiveness and success of the work are due, in a very large measure, to the type of operator. He must be the owner of the farm and engaged in no other work. He should be public spirited, a man in whom the people have confidence and from whom they will seek advice, a man who is willing and ready to share his ideas in a neighbourly way. He must, of course, be interested in the work and in all forms of agricultural improvement. It is desirable that he should have somewhat of an experimental turn of mind and that he should be careful in his work and accurate in recording results. The illustration work is entirely a coöperative undertaking. For that reason the operator must be ready to follow instruction and have an open mind in regard to questions of change if the work is to progress.

Location has a great deal to do with popularizing the work and giving it educational value. The station should be on a main highway, preferably near a town or centre of community interest so that neighbouring farmers, in passing, can view the progress of the work throughout the season. Each field in the Station should have frontage on the main road. Suitable signboards are erected describing the variety of crop, rates of seeding and fertilizer applications so that the Station provides a living illustration of the idea and purpose behind the work.

*Part of an address delivered at the eighth annual convention of the B.C. branch of the Canadian Society of Technical Agriculturists held at Vernon, B.C., on March 31st, 1928.

†Supervisor of Illustration Stations in British Columbia.

The area selected for the site of the Illustration Station contains from 12 to 40 acres of land. It is highly desirable that the soil and general condition be typical of that in the district. Five dollars per acre per annum is paid by the Dominion Government for the land included in the Station. This compensates the operator for the time required to take records and extra work in keeping the fields tidy. Seed is supplied to the operator, for the first year at least. He is expected to save seed for succeeding crops. The crop belongs to the operator.

No wages are paid for work on the Station and no equipment is supplied by the Department. Use is made of the equipment that the operator has at hand and generally his farm is in much the same stage of development as his neighbours. This is one of the strong features of the work, for any improvement on the Illustration Station can readily be adopted by neighbouring farmers.

The Illustration Station is equipped with a rain gauge and maximum and minimum thermometer. Daily weather records are kept by the operator and sent in to headquarters regularly.

The operator keeps a record of all work done on the Illustration Station fields throughout the year.

Cost records are kept of all crops on the Station for the purpose of showing that growing good seed and following improved methods are profitable.

Field Days are held on the Stations during the growing season at which the University, branches of the Dominion Department of Agriculture and the Provincial District Agriculturists are represented. Visitors are conducted on a tour of the illustration fields and the various phases of the work are discussed and demonstrated. The Farmer's Institutes co-operate at each point to make the day a success and usually provide refreshments and entertainment.

Work with Live Stock

Live stock improvement is an important feature of the Illustration Station's programme of work. Pure-bred dairy sires, boars, rams and cockerels are sold to the Illustration Station operators at a preferred price. No definite schedule of prices is set but the policy of selling the animals, rather than loaning, seems to be sound. The price charged is made to fit the man and not the animal. In this way the Experimental Farm acts as a feeding station of good stock to the Illustration Station which, in turn, is a distributing centre for better live stock in the community which it serves. To perform this service adequately most of the operators are maintaining good foundation stock and providing proper housing. Pure-bred poultry flocks are kept on ten out of the twelve stations, pure-bred pigs on eight stations and pure-bred dairy sires on six stations. Three new barns have been built in the last three years to accommodate increased dairy herds, and five new poultry houses have been constructed by the operators within the same period.

Encouragement and assistance are given in improving the home grounds on the farm on which the Illustration Station is located so that the farmstead will be an example to neighbouring farmers. There is opportunity

along this line for a great deal of useful work which is enlarging from year to year.

Seed Growing and Variety Testing

One of the most important phases of the Illustration Station work is the growing and sale of good seed. The operator is supplied with the best Canadian grown seed obtainable. This is grown on the Station and sold by the operator to neighbouring farms. In this way the crops in the district are improved and good seed more widely distributed. The work is practical and conducted under field conditions. The purpose of the work is primarily demonstrational, not experimental. The research and testing are carried out on the Experimental Farms and through the Illustration Stations the results of these investigations are carried out to the farms in all parts of the Province and put into operation in a practical way in the field.

Although the primary function of the Illustration Station is demonstrational, there are certain agricultural localities in the Province, remote from the Experimental Farms, which have natural conditions peculiar to themselves. Such is the situation in Central British Columbia where facilities are lacking for comprehensive experimental work. Here, with the co-operation of interested operators and farmers in this district, the Division of Illustration Stations is conducting experimental work in a small way with various forage crops. Each operator along the line of the Canadian National Railway has set aside an acre of his best land for plot testing work. Much valuable information has been obtained in regard to kinds and varieties of crops best adapted to Central Interior conditions. The work has an important educational value in acquainting the farmers in the district with different types and varieties of grasses, where they can compare their growth and behavior under local conditions. The tests also assist the farmer to decide upon suitable mixtures for the field. Tests are first made in a small way on the plot and if successful are extended to a larger area under field conditions.

Variations in Soil and Climate

The crop rotation forms the basis of the crop improvement work on the Illustration Stations. The type selected is one which will fit the kind of crops that can be grown advantageously and is adapted to the most desirable system of farming in the district.

In the Province of British Columbia, on the twelve stations at present fully established, there are six different types of rotations under way. In laying out a rotation and selecting the various crops it is well to bear in mind the remark of a farmer's wife in the northern country. "We have to make our living up here," she said, "not with what we would like to grow, but with what we *can* grow." There is a great deal of common sense in that simple remark and it must always be borne in mind in laying out a cropping system.

The various types of rotation in B. C. are made necessary on account of the wide variation in soil and climate. A glance at the meteorological table for B. C. will show this. Rainfall ranges from 75 inches per annum at the Alberni Station on Vancouver Island to 15 or 20 inches in Central

British Columbia and 10 or 12 inches in the Southern Interior. Minimum winter temperatures varied last winter between 14° above zero on the Island to 56° below zero in Central British Columbia.

Over such a large extent of territory as Central British Columbia soil is naturally variable. Generally it is a clay subsoil, topped with one or two inches of vegetable mould. In the Bulkley Valley soil is more loamy in nature, in the Vanderhoof district it presents the appearance of a fine white clayey silt, while further east in the Prince George and McBride areas there is a preponderance of clay.

On the Vancouver Island Station soil varies between a light clay loam to a light sandy loam. At Kamloops it is a deep rich loam and at the Armstrong Station a heavy clay.

In Central British Columbia fall work usually ends on October 20th and work on the land commences in the spring, about April 20th. On Vancouver Island work on the land continues throughout the winter months. Seeding dates in Central British Columbia range from April 20th to May 10th, hay cutting July 1st to 15th and grain harvesting August 20th to September 1st. The maximum growing period for vegetation in Central British Columbia is estimated at 175 to 180 days. In the north Okanagan the average number of growing days is 200 while on Vancouver Island the growing period extends from 250 to 270 days.

Demonstration and encouragement in the growing of clover and alfalfa have been the main objectives of the Illustration Stations in Central British Columbia since work was undertaken in 1922. On Vancouver Island fertilizer work is the main project on the stations. Other parts of the Province, where Illustration Stations are located, have problems peculiar to their district to which the Station is giving its attention. This elastic form of organization and adaptation to local conditions is among the strong features of the Illustration Station work.

Coöperation and Extension

In addition to the Illustration Station work in the Province, irrigation and orchard cover crop demonstrations are conducted at Grand Forks in the Boundary district in coöperation with the District Agriculturist. For two years alfalfa tests were conducted on two-acre blocks with 15 farmers in the Armstrong district. Last year alfalfa tests with cut worm control measures were undertaken on ten two-acre blocks in the Armstrong district in coöperation with the Dominion Entomological Branch. Corn variety tests with eighteen farmers on one-acre blocks have been carried on at Salmon Arm for three years. On Vancouver Island, in coöperation with the Provincial Department of Agriculture, ten one-acre test plots were set out on which lime and fertilizer tests were undertaken. In coöperation with the University of British Columbia fall wheat tests are being conducted in the Central Interior and the Experimental Stations and the University are coöperating in a test of northern vs. locally grown potatoes. These tests have been in progress for four years.

The forage crop variety testing project in Central British Columbia, started in 1924, was extended in 1926 and 1927 to include interested farmers

in the district surrounding the Illustration Stations. On the Illustration Station farms these small experimental blocks were enlarged and to approach field conditions more nearly, plots, the width of a grain drill and one chain in length, were established so that all seed is sown and the crop handled with field implements. The plots contain straight varieties and mixtures of fifteen grasses, eight clovers, and eight annual fodder crops. Notes are made periodically on germination, comparative growth, strength of stand, winter hardiness and second growth.

One of the most satisfactory pieces of work that the Dominion Experimental Farms Branch has undertaken in the central interior is the clover and alfalfa demonstrations. Canadian grown clover seed was supplied in 1925 for one acre test blocks to over ninety farmers along the line of the Canadian National Railway between McBride and Hazelton. Under a wide range of soil types the men undertook to test out these fodder plants under field conditions. All plots were inspected and condition reported.

Results have been most encouraging for the success of the trials has given confidence to farmers to extend their acreage in these crops. In 1926 the operator of the Vanderhoof Illustration Station, along with a neighbour, made up the first car of alfalfa loaded in central British Columbia, and last season the operator at Telkwa shipped the first car of alfalfa hay from the Bulkley Valley.

Work with clovers and alfalfas from a hay production standpoint is now well beyond the experimental stage. After tests under plot and field conditions had shown quite conclusively that these forage plants were adaptable to the central interior climate and soil, the Division turned its attention to commercial clover and alfalfa seed growing.

In 1926 the Experimental Farms Branch distributed pure strains of clover and alfalfa seed to thirty-five farmers along the line of the Canadian National Railway in order to test out these crops for seed production under central British Columbia conditions. One-acre blocks of Ontario variegated alfalfa, common red clover and alsike clover, all Canadian grown, were set out under the direction of the Division of Illustration Stations.

Last season seed was harvested from several plots and averaged about 100 pounds to the acre. Samples forwarded to the Dominion Seed Laboratories graded satisfactorily, with germination on alfalfa samples showing 98 per cent and clover 99 per cent. Clover and alfalfa seed from central British Columbia were interesting features at the Interior and Vancouver Winter Fairs. A number of enterprising farmers in the Central Interior grew considerable acreage of their own seed without assistance from the Department.

In view of the amount of seed grown this year and the prospect of annual increase, the Provincial Department provided seed cleaning plants at Prince George and Vanderhoof. This is the first year that clover and alfalfa seed has been grown in central British Columbia in commercial quantities and marks another stage in the agricultural development of this section of the Province.

A TRAVERS LES REVUES

NOS CONNAISSANCES ACTUELLES CONCERNANT L'ACIDITE DU SOL.

Dans le numéro de janvier de cette revue, nous avons donné un petit exposé de la signification de la valeur pH dans l'expression de la réaction du sol et des autres milieux. Comme complément de cette étude, beaucoup d'agronomes seront peut-être heureux d'avoir un bref résumé de ce que l'on sait actuellement concernant l'origine ou la nature de l'acidité du sol. Il n'y a peut-être pas, en effet, de problème de la Science agricole qui fasse couler plus d'encre depuis quelques années dans les revues techniques, alors qu'il n'y a pas encore bien longtemps les manuels de chimie agricole croyaient pouvoir nous fixer en quelques paragraphes sur toute la question. Nous empruntons à la publication néerlandaise *"Onze Ploeg"*, paraissant à Louvain, les notes suivantes que nous traduisons librement d'un article intitulé *"Zuurheid van den Grond"*, sous la signature de A. Van Olmen, ingénieur chimiste agricole. Elles résument d'une façon brève et claire ce que l'on peut conclure d'une foule de travaux effectués par des savants de divers pays et permettent à tous les agronomes qui n'ont pas le temps de suivre les nombreux articles de revues, de se mettre, sans peine, au point sur la question.

La Notion Ancienne Concernant l'Acidite du Sol.

Il n'y a pas de cultivateurs qui n'ait entendu parler de terres acides, surtout par rapport aux prairies et pâturages. Les praticiens ignorent naturellement la nature de ce phénomène, mais ils en connaissent généralement assez bien les indices et les effets. C'est ainsi qu'ils ont observé les plantes de qualité médiocre qui se développent de préférence en milieu acide ou souffrant d'un excès d'humidité, et dont on trouve la nomenclature dans tous les bulletins et manuels traitant de la fertilité du sol.

De tout temps encore, il était connu que l'acidité du sol pouvait être combattue par l'égouttement et le chaulage. Et si à cela on ajoute que la pratique établissait une distinction entre plantes calcicoles (telles que la plupart des légumineuses) et plantes calcifuges (telles que la pomme de terre), nous aurons mentionné à peu près ce qui s'enseignait dans les manuels d'agriculture pratique, concernant l'acidité du sol.

L'ancienne chimie agricole entrait naturellement dans un peu plus d'explications. Elle attribuait la réaction acide du sol, principalement à la formation d'acides humiques résultant de la décomposition de matières organiques dans un milieu gorgé d'eau ou manquant de chaux. Notons que l'on est plus que jamais dans l'incertitude relativement à la composition réelle de ces acides humiques dont on avait tenté autrefois d'établir les formules.

L'acidité elle-même se constatait au moyen de petites bandes de papier de tournesol bleu qui virait en rouge par son contact avec la solution du sol. D'autre part, on considérait qu'un échantillon de terre qui produisait de l'effervescence au contact d'une solution d'acide chlorhydrique était riche en chaux et, par conséquent, pas acide. Nous savons aujourd'hui que ces essais qualitatifs ne sont pas très exacts. D'abord on a vu dans l'exposé concernant la signification de la valeur pH, combien élastique, indéterminée, est en réalité

le degré d'acidité qu'indique le changement de couleur du papier de tournesol; d'autre part, on sait aussi qu'il peut y avoir dans le sol des substances non acides qui peuvent faire virer au rouge la teinture de tournesol. Enfin, il est encore prouvé que certaines terres qui exigent un apport d'amendement calcaire peuvent cependant produire une effervescence assez notable, par la décomposition du $CaCO_3$ au contact de HCl.

Au laboratoire, on pratiquait aussi des déterminations quantitatives de l'acidité, par titrage de la solution du sol à l'aide d'une solution alcaline d'un titre connu. Le grand défaut de cet essai provenait du fait qu'on ne possédait pas d'indicateur convenable; ainsi le titrage avec la phénolphtaléine donne un résultat très différent de celui effectué avec l'aide du méthylorange.

Il était facile aussi d'établir par un procédé gravimétrique ou pesée, le pourcentage total de chaux contenue dans un échantillon de sol; mais cette dose totale de chaux ne nous apprend rien concernant la quantité de chaux qui est réellement disponible pour les plantes. Il faut bien savoir, en effet, que la chaux peut être fixée tellement énergiquement (adsorbé, comme on dit ordinairement) par les colloides de l'humus et de l'argile, que les plantes ne peuvent guère se l'approprier. La détermination quantitative de l'acidité du sol et de la chaux qu'il contient, par l'ancien procédé chimique, était donc également défectueux au point de vue des conclusions à en tirer.

Une méthode satisfaisante d'établissement de la réaction du sol et de mesure de son acidité ne fut trouvée qu'à la suite de travaux basés sur la théorie d'Arrhénius, expliquant l'état de dissociation des acides et des bases dans l'eau.

Nous avons exposé, dans l'article paru dans le numéro du mois de janvier 1928, comment la concentration des ions hydrogène, qui est l'exacte mesure de l'intensité du le'acidité, pouvait être trouvée au laboratoire, au moyen du potentiomètre ou électrode à hydrogène. On se rappellera aussi la signification des différentes valeurs pH, indiquées par le potentiomètre. Enfin, nous avons parlé encore de la révolution à laquelle nous assistons depuis l'introduction dans la pratique courante, d'une foule d'indicateurs nouveaux dont les changements de couleur sont gradués d'après les valeurs fournies par l'électrode à hydrogène.

De tout cela, il semble qu'on peut conclure que le vieux papier de tournesol est rélégué, en laboratoire, à peu près au même rang que la faucille en mécanique agricole.

Mais maintenant se pose encore la question:

Quelle est l'Origine de l'Acidite du Sol?

Quelque regrettable que ce soit, jusqu'ici la science n'est pas encore en mesure de fournir une réponse définitive à cette interrogation.

Il est un fait incontestable, c'est que quelques terres peuvent indiquer un état d'acidité active par suite de la proximité de certaines usines qui rejettent des vapeurs d'acides minéraux forts, tels que HCl, HNO_3 et H_2SO_4, lesquelles parviennent au sol en dissolution dans les précipitations atmosphériques.

Mais en dehors de ce cas, qui est une exception, d'où viennent les ions H ou l'acidité active?

D'après les travaux faits en la matière, nous pouvons nous représenter l'origine de ces ions comme suit:

Le sol renferme de l'argile et de l'humus, deux substances dont la composition chimique n'a pu être établie exactement jusqu'ici et que l'on désigne, de ce fait, sous la dénomination générique de substance argileuse et humique.

Or, nous pouvons nous représenter la substance argileuse et humique comme des acides qui peuvent être saturés par des bases, et dans la pratique agricole, ils doivent l'être par la chaux.

On discute encore la question de savoir si cette saturation constitue une combinaison chimique proprement dite ou bien un phénomène dit d'absorption (qui serait plutôt de nature physique, c'est-à-dire ne suivrait pas la loi des proportions définies). A noter que le plus souvent on admet le phénomène d'absorption. Or, tant que la substance argileuse et humique n'est pas complètement saturée avec des bases, elle cèdera, par elle-même ou par réaction, des ions H libres, à la solution du sol. Le dernier mot n'est pas dit à ce sujet; des recherches ultérieures devront encore élucider la question. Nous pouvons donc admettre provisoirement que l'acidité active dépend de la nature de l'humus et de l'argile, dans les conditions ordinaires. L'expérience démontre que les acides argileux sont des acides faibles, ils indiquent une valeur pH supérieure à 6, tandis que les acides humiques sont beaucoup plus énergiques, possédant un pH qui va jusqu'à 4. Les acides argileux ne font presque pas dégager d'anhydride carbonique par leur contact avec du $CaCO_3$, tandis que les acides humiques en font dégager de fortes quantités, déjà à la température ordinaire.

Quel est l'Agent Nocif a la Vegetation dans un Sol Acide?

Les auteurs ne sont pas d'accord non plus pour la réponse à donner à cette question. Plusieurs investigateurs pensent que c'est l'ion *Al* des sels d'aluminium qui passent dans la solution du sol sous l'influence des acides qui est préjudiciable à la végétation des plantes. Dans un même ordre d'idées, on attribue parfois aussi à des composés solubles du fer et du manganèse l'effet préjudiciable constaté. Le plus souvent, cependant, on admet aujourd'hui que le tort causé aux plantes provient de l'acide lui-même. Il est prouvé notamment que pour une valeur pH inférieure à 5 l'effet nocif devient très considérable.

On ne peut expliquer davantage comment l'acidité exerce son mauvais effet sur la plante. On pourrait supposer que les acides du sol agissent sur les poils radicaux de façon à mettre obstacle à une assimilation normale des principes nutritifs, par exemple, à la suite d'une différence de réaction entre le milieu intérieur et extérieur de la plante, telle que les échanges deviennent impossibles.

Une chose certaine aussi, c'est que l'acidité peut modifier en une large mesure la structure même du sol. Un terrain argileux acide affecte généralement une structure compacte qui s'oppose à l'aération et crée de ce fait même des conditions défavorables à la végétation. Nous pourrions d'ailleurs ajouter aussi qu'il est bien connu que les bactéries les plus utiles à la nutrition des plantes supérieures, telles que les azotobacter et les organismes nitrifiants, disparaissent dans un sol acide.

Croissance des Plantes en Rapport avec la Reaction du Sol.

On sait, ainsi que nous l'avons dit, depuis longtemps que les plantes se comportent différemment vis-à-vis de la réaction du sol, les unes s'accommo-

dant et préférant même un sol légèrement acide, les autres exigeant un sol neutre ou légèrement alcalin.

Voici maintenant un tableau qui donne, d'après le professeur allemand Trénel, les limites entre lesquelles se trouveraient les valeurs pH les plus favorables à la croissance des plantes cultivées mentionnées ci-dessous:

Plantes.	pH
Pommes de terre	5 à 6
Avoine	5 à 6
Seigle	4 à 7
Blé	6 à 7
Orge	7 à 8
Betteraves à sucre	6 à 7
Pois	6 à 7
Trèfle	6 à 7
Luzerne	7 à 8

Il semble prouvé que toute végétation cesse en dessous d'un pH de 4 et au dessus d'un pH de 8.5.

Le tableau ci-dessus nous indique donc que la plupart des plantes cultivées se trouvent le mieux d'une réaction du sol allant du faiblement acide au neutre. Nous voyons aussi que les pommes de terre, de même que l'avoine et le seigle, supportent le degré d'acidité le plus élevé, tandis que la luzerne requiert un sol légèrement alcalin.

D'après Stoklasa, le pH des prairies et pâturages acides de mauvaise qualité, varie entre 4 et 6, alors que pour les mêmes terrains en bonne condition sa valeur oscillera entre 6.7 et 7.3.

Saturation de l'Acidite du Sol.

Nous savons donc que le potentiomètre ou électrode à hydrogène fournit un moyen de déterminer exactement le degré d'acidité, quoique la nature même de celle-ci et la manière dont elle influence la croissance des plantes soient encore mal élucidées.

La question pratique qui se pose alors est la suivante: que faut-il faire pour atteindre le pH favorable au développement normal des plantes de nos récoltes?

Il est connu de longue date que les sols acides peuvent être amendés par des applications de matériaux calcaires. Mais il n'était guère question autrefois d'établir une proportion déterminée entre le degré d'acidité et la quantité de chaux à appliquer. Aussi, dans la pratique, il arrivait que l'on constatat que certaines terres restaient acides malgré de fortes additions de matières calcaires, alors que d'autres devenaient trop alcalines après des applications beaucoup moins grandes de chaux. Au point de vue pratique on peut donc se demander s'il y a une relation déterminée entre le pH du sol et son besoin en chaux; ou, en d'autres termes, le pH d'une terre étant connu, peut-on calculer exactement la quantité de chaux qu'il faudra lui incorporer pour créer l'état de réaction favorable aux plantes?

On a essayé de donner des recettes dans ce sens. Ainsi, le professeur Grégoire, de Gembloux, dans un bulletin publié par le Ministère de l'agriculture de Belgique, indique en regard des différentes teintes du tableau

en couleurs de la réaction de Comber, les quantités respectives de chaux qu'il s'agira d'appliquer. Ces quantités varient entre 500 et 2,000 kilogrammes de CaO par hectare (soit 440 à 1760 lbs. à l'acre). L'auteur de cet aperçu est d'avis que cette indication est fort hasardée et il ajoute qu'il ne voudrait certainement pas y souscrire. Hudig préconise la méthode suivante pour les terres sablonneuses riches en humus. Chercher la quantité de $CaCO_3$ qu'il faut ajouter à un poids donné d'humus pour lui communiquer une réaction neutre. C'est ce qu'il appelle *la condition de chaux.* Ainsi une condition de chaux de –30 veut dire qu'il faudra ajouter 30 lbs de $CaCO_3$ à 1000 lbs d'humus pour amener celui-ci à l'état de neutralité parfaite. D'après Hudig, la condition de chaux la plus favorable à la majorité des cultures correspondrait à –10, mais lorsque les pommes de terre n'interviennent pas dans la rotation, il est préférable de maintenir la condition de chaux à 0.

Christenzen, un savant danois, s'est basé sur le développement des azotobacter pour juger du besoin de chaux du sol. Selon lui, une terre dans laquelle les azotobacter se développent normalement n'a pas besoin de chaux. Au Danemark, plus de 35,000 échantillons de terre ont été essayés à ce point de vue. En Hollande, Hissink a proposé encore une autre méthode pour mesurer la quantité de CaO dont a besoin le sol. Il chercha combien de grammes de CaO devaient être absorbés par 100 gr. d'humus pour atteindre un pH de 7. Il donne à cette quantité de CaO le nom de *facteur de chaux.*

Le Dr Trénel prétend qu'il n'existe pas de rapport fixe entre le pH et le besoin de chaux, mais que ce besoin en chaux dépendra de la nature de l'acidité. Selon lui, un pH inférieur à 5 serait l'indice de la présence d'acides forts (fortement dissociés) ; un pH supérieur, c'est-à-dire une acidité moins intense, correspondrait à des acidités faibles. S'il n'y a que des acides faibles dans le sol, il s'agira de chauler avec circonspection, parce que de tels sols sont exposés à être chaulés avec excès. En effet, nour la neutralisation d'acides forts, par une base, le point de saturation et celui de neutralisation (pH=7) se confondent; pour des acides faibles, au contraire, le point de saturation est plus élevé que le point de neutralisation. Il s'en suit que des terres avec un pH supérieur à 5, qui ne contiennent que des acides faibles, passeront rapidement à la réaction alcaline à la suite d'applications de chaux.

Conclusions Pratiques.

L'auteur qui a essayé d'exposer les points principaux des recherches récentes concernant l'acidité du sol, estime que les opinions des différents investigateurs sont encore fort indéterminées et parfois contradictoires, ce qui est la meilleure preuve que la solution du problème n'a pas encore été trouvée.

Il se demande ce que l'agriculteur pratique peut en conclure jusqu'ici. La détermination du pH du sol par voie électrométrique fournit des résultats certains, mais alors se pose la question, peut-elle être introduite d'une manière générale dans la pratique? Pour cela il faudra encore trouver un appareil pratique et fonctionnant d'une manière exacte. La méthode colorimétrique est beaucoup moins sûre et doit toujours être contrôlée par la précédente.

Les questions: qu'est-ce qu'au juste que l'acidité du sol? d'où provient cette acidité? comment agit-elle sur les plantes? demeurent à peu près non résolues. Il n'est pas encore possible d'indiquer la quantité exacte de chaux qui est nécessaire pour neutraliser une acidité de grandeur connue. Et c'est ce qu'il y a de plus regrettable dans toute l'affaire, puisque le centre de gravité de toute la question de l'acidité du sol est situé là.

Si la chimie agricole pouvait indiquer au cultivateur un moyen pour calculer d'une manière suffisamment approximative le besoin de chaux de son sol, elle rendrait certainement un grand bienfait à l'agriculture. Espérons qu'elle y parviendra un jour.

Le grand mérite—mais le seul pour le moment—de toutes ces études, est, suivant l'auteur, que grâce à elles l'attention a de nouveau été fixée par le chaulage du sol.

Au cours des 20 dernières années, la pratique du chaulage des terres avait beaucoup diminué (l'auteur a sans doute en vue les pays de l'Europe Occidentale, tels que la Belgique, la Hollande, la France, etc.), et d'un autre côté l'emploi d'engrais chimiques qui appauvrissent le sol en chaux a beaucoup augmenté. La chaux est donc devenue nécessaire un peu partout. Il suffira déjà que cette conclusion pénètre partout dans la pratique pour faire une bonne avance dans la voie du progrès. H. M. N.

ACTIVITES DES SECTIONS

Section de Quebec et Ontario Nord.

Nous avons reçu une communication de monsieur Alexandre Rioux, secrétaire-trésorier de la Section Québec et Ontario Septentrional, à Macamic, Abitibi, nous donnant des détails très intéressants concernant les activités de cette jeune section au cours de l'été dernier.

Elles sont la preuve que le bel enthousiasme qui a présidé à sa fondation, il y a près d'un an, n'a pas été un feu de paille; la dissémination jointe aux difficultés de communications qui caractérisent le grand territoire du nord-ouest des deux provinces semblent n'être qu'un stimulant de plus pour resserrer les liens sociaux et multiplier les relations professionnelles entre les techniciens agricoles qui l'habitent.

C'est ainsi qu'ils tinrent une assemblée de trois jours, les 25, 26 et 27 juillet, à Ville-Marie (Témiscamingue), où les travaux sérieux alternèrent avec des séances récréatives dont certains talents bien connus firent les frais.

Au cours de ces réunions, deux comités furent constitués comme suit: *a*) Un Comité de Publicité,ayant comme président monsieur Raoul Hurtubise, inspecteur des semences pour le Témiscamingue et le Nouvel Ontario, avec messieurs L. J. Bégin et France Brien, respectivement agronomes du Témiscamingue et de l'Abitibi-Est. *b*) Un Comité d'étude, président monsieur Pascal Fortier, régisseur de la station expérimentale de la Ferme, avec messieurs L. H. Hanlan, assistant-régisseur de la station expérimentale de Kapuskasing, Daniel Pomerleau, agronome officiel de Cochrane, et Armand Joubert, assistant agronome de l'Abitibi.

L'objectif du premier comité est de promouvoir le développement agricole du nord de Québec et de l'Ontario; le second a pour mission de recueillir

les publications concernant les diverses méthodes de culture et d'élevage qui paraissent dans les revues et les journaux, de les étudier et de les rendre applicables aux conditions du nord, pour les publier ensuite sous une autre forme, mieux adaptée aux besoins des cultivateurs de la région.

La pièce de résistance de la réunion des techniciens agricoles de la Section Québec et Ontario Septentrional, fut une conférence faite par monsieur Eugène Filiatrault, aviculteur de la station expérimentale de La Ferme, traitant des "quatre races et variétés de volailles les plus populaires sur nos fermes aujourd'hui."

Après avoir déclaré qu'il n'avait de parti pris pour aucune race, monsieur Filiatrault nomma les quatre races suivantes: Plymouth Rock barrée, Rhode Island rouge, Wyandotte blanche et Leghorn blanche. Il fit remarquer aussi que la plupart des autorités en agriculture nous disent que toutes les races sont bonnes et recommandent de choisir la race qui a nos préférences. Cependant il ne partage pas entièrement cette opinion, car pour gagner de l'argent dans l'industrie avicole il faut se conformer aux exigences du marché local, produire des volailles pour la chair là où celle-ci est demandée, et garder une race spécialement adaptée à la ponte là où l'on trouve un très bon marché pour les œufs.

Le conférencier fit ensuite un tableau de chacune de ces races en indiquant la place qu'elle occupe dans la classification des volailles, ce que l'on connaît concernant leur origine, leurs caractères et leurs aptitudes. Il fit ressortir les qualités dominantes et les points faibles qui leur sont particuliers respectivement.

Le chansonnier du corps agronomique, France Brien, agronome à Amos, remporta la palme dans la partie du programme consacrée aux soins de la rate, avec sa chanson "Impressions de voyage de la C. S. T. A., à Ville-Marie."

Section de Ste-Anne de la Pocatiere

Un grand nombre d'agronomes et experts en agriculture de l'Est de Québec s'étant réuni à Ste-Anne pour assister à la grande exposition de chevaux des comtés de Témiscouata, Kamouraska, l'Islet et Montmagny, la section locale de la Société des Agronomes Canadiens en profita pour reprendre ses séances d'étude spéciales.

M. Charles Gagné, M.S.A., professeur d'économie rurale à l'Ecole d'Agriculture de Ste-Anne, fut le conférencier de la soirée et traita du "Développement de la pomme de terre dans le monde, les Etats-Unis et les Provinces canadiennes".

Résumé de la Conférence de M. Charles Gagné.

Les naturalistes les plus compétents s'accordent pour reconnaître les parties montagneuses du Chili et du Pérou comme le pays d'origine de la pomme de terre. De ces endroits, le tubercule se serait propagé en Amérique et en Europe.

Les botanistes européens en ont commencé la culture à la fin du 16^{me} siècle. Cependant, deux cents ans plus tard, l'économiste anglais Arthur Young pouvait dire de la pomme de terre, après avoir parcouru plusieurs contrées du continent européen, que "les 99 centièmes de l'humanité n'y voudraient pas toucher".

Des savants ont acquis la célébrité pour avoir contribué à rendre populaire la consommation de ce tubercule parmi certaines populations. Tel fut le cas de Parmentier, en France.

Nos voisins du Sud prétendent ne s'être occupé de sa culture qu'après 1719, alors qu'on s'avisa d'en importer d'Irlande.

Au Canada, d'après notre archiviste provincial M. P.-G. Roy, des Indiens auraient connu la pomme de terre dès 1605. On cite plusieurs témoignages qui confirment cette opinion. Cependant, le naturaliste suédois, Pierre Kalm, écrivait, en 1749, que peu de gens connaissaient la pomme de terre en notre pays.

Mais s' il a fallu plus de deux siècles aux peuples de race blanche pour apprécier les avantages de la pomme de terre, il faut bien admettre qu'aujourd'hui ils en font une bien forte consommation.

M. Brunhes estime la production des pommes de terre du monde à environ 1500 millions de quinteaux métriques. Sous le rapport du poids, la récolte mondiale des pommes de terre serait supérieure à celle du blé et un peu inférieure à celle du riz.

On sait que le sort des Irlandais n'était guère enviable au 19me siècle. Une loi adoptée en 1829 avait enlevé aux petits paysans irlandais le droit de vote. Ceux-ci se voyaient en outre imposer des fermages de famine par les 744 landlords qui possédaient plus de la moitié de la surface du sol de leur pays. Ils ne pouvaient toucher ni aux céréales, ni aux produits de l'élevage. Ces biens appartenaient aux seigneurs qui les exportaient à leur profit. Il ne restait aux paysans que la pomme de terre.

A l'automne de 1845 se produit un désastre; en quelques jours, les trois quarts des tubercules sont détruits; en 1846 et en 1847 les récoltes sont nulles. Aussi, de 1846 à 1849, le règne atroce de la famine va croissant parmi le peuple irlandais, tandis que les landlords exportent le blé, l'orge, l'avoine et le bétail.

Les Irlandais émigrent alors en masse vers l'Amérique.

En 1846, la population de l'Irlande était de 8 millions et demi d'habitants, et en 1911 elle n'était que de 4,390 personnes.

M. Brunhes, commentant ces faits, écrit: "En comparaison d'une pa-"reille ruine, que sont les désastres d'un cyclone ou d'un tremblement de "terre, que sont les dévastations humaines dues au caprice d'un sultan sou-"danais ou même aux péripéties d'une guerre entre nations civilisées? Notre "esprit a de la peine à saisir toute l'amplitude du contre-coup durable pro-"duit par un fait cultural comme celui-ci."

L'Allemagne doit à la pomme de terre une grosse part de son développement économique contemporain. C'est Vidal de la Blache qui nous apprend que la pomme de terre a grandement contribué au succès du développement des bassins houilliers de l'Allemagne septentrionale en assurant à la population de ces régions un aliment sain et abondant.

Objet de la production.

On cultive la pomme de terre pour deux fins: l'alimentation des humains ou des animaux et sa transformation industrielle. En Amérique du Nord, nous ne cultivons guère de patates pour des fins industrielles, l'amidon du maïs étant préféré à celui de la pomme de terre pour cela. L'industrie

n'utilise, à vrai dire, que les déchets de nos cultures de patates. En Europe, particulièrement en Allemagne, en Pologne et dans l'Est de la France, la culture de la pomme de terre industrielle,—plus riche en fécule que celle destinée à notre alimentation—est très importante. L'Allemagne retire de gros revenus de l'alcool qu'elle obtient de la pomme de terre.

Au Canada et aux Etats-Unis.

Les Américains produisent de grosses quantités de patates. La valeur de cette culture représentait, chez eux, en 1925, environ les deux-tiers de la valeur de leur récolte de blé, soit plus de 600 millions de dollars. Ils consomment plus de 98% de leur production.

On distingue plusieurs zones importantes de la production de la patate aux Etats-Unis. D'abord les Etats à production hâtive tels que les deux Caroline, la Floride, l'Alabama, la Californie et les régions entourant le golfe du Mexique qui vendent leur récolte nouvelle du mois de mars à la fin d'août. Il y a la zone de production intermédiaire qui reproduit des patates hâtives et des patates d'automne: Virginie et New-Jersey. Enfin, on mentionne la zone de production tardive qui comprend les Etats du Maine, du New-York occidental, le Michigan, le Wisconsin, le Minnesota, et le Dakota du Nord. Nous ne mentionnons pas ici les régions dont la production est consommée presque sur place, comme par exemple celle de Long Island, qui est dans la banlieue de New-York, et dont la récolte est vendue dans cette ville même.

La valeur de la production canadienne de pommes de terre représente environ de 1-15 à 1-18 de la valeur totale de toutes nos récoltes. Ainsi, en 1926, nos pommes de terre étaient évaluées à environ 60 millions de dollars et toutes nos récoltes à 1126 millions.

Presque toute notre production de patates consiste en pommes de terre d'automne. Nous n'avons que deux régions d'une certaine importance qui produisent des patates vendables en juillet, la Colombie Anglaise et les comtés de Kent et d'Essex en Ontario.

Commerce.

Nous vendons un faible pourcentage de notre production nationale à l'étranger, surtout aux Etats-Unis et aux Antilles. Nos importations représentent, en quantité, moins d'un dixième de nos exportations. Nous achetons des Américains des pommes de terre hâtives en avril, mai, juin, juillet et août.

En fin de soirée, M. l'abbé Jean, M. S. A., professeur de génétique à l'Ecole d'Agriculture, nous parla d'un voyage récent qu'il fit au "Royaume de la pomme de terre".

E. C.

Nouvelles de nos Membres.

Nous sommes informés que monsieur Philippe Granger, B.S.A. de l'Institut Agricole d'Oka, du mois de juin 1928, a été nommé assistant-régisseur à la Ferme expérimentale des tabacs de l'Assomption.

Monsieur Fernand Corminboeuf, B.S.A. de la même institution, année 1927, a été demandé comme professeur d'agriculture au Collège de Gravelbourg, Saskatchewan.

BOOK REVIEW

Physiology and Biochemistry of Bacteria. Vol. I. Growth Phases, Composition and Biophysical Chemistry of Bacteria and their Environment; Energetics. By R. E. Buchanan and Ellis I. Fulmer. (Williams and Wilkins Co., Baltimore, 1928. Pp. 516, fig. 78. Price $7.50.)

The intimate relationship existing between microbiology and biochemistry, which is becoming increasingly manifest, has created an urgent need for a handbook on the physiology of bacteria and other microörganisms. The bacteriologist, up to the present, has been forced to rely upon such widely scattered, and often not readily accessible, references to biochemistry and biophysics as applied to bacteria that the appearance of a work in which the main facts of microbial physiology are gathered in one or two volumes is most timely.

In this, the first volume of what is presumably a two-volume work, the subject matter is divided into five chapters. Following a short, 3-page introductory chapter, Chapter II, comprising 59 pages, deals with growth phases and growth rates in cultures of microörganisms. Chapter III treats, in 76 pages, of the chemical composition of the cells of microörganisms, while Chapter IV, quite the longest in the book, covering 234 pages, deals with the physicochemical and physical characteristics of microörganisms and their environment. Chapter V, the last, treats of energy relationships, growth and movement of microörganisms in a space of 90 pages. Following the text comes an appendix containing references to the literature cited, while author and subject indices complete the volume.

To judge properly the worth of the work on the basis of this volume alone is hardly possible, for much will depend upon the matter contained in the second volume which may be expected to make its appearance in due course. One is inclined to wonder, however, whether the authors have not wandered too far into the domain of pure physics and physical chemistry and included much that might properly have been left to the works in those fields. Doubtless the second volume will be more directly concerned with microörganisms themselves in their various physiological aspects, and it may be that when this appears and the work can be judged as a whole, the seeming over-allotment of space to an extensive presentation of the principles of pure physics and chemistry may appear justified.

The book contains much which makes it a welcome addition to microbiological literature, and with the appearance of the second volume, the work as a whole will doubtless be found to be a most valuable guide and reference book, not only because of its scope, but also on account of the clear manner in which the material, of a type difficult to coördinate, has been presented by the authors.

A.G.L.

CONCERNING THE C.S.T.A.

Editorial Policy.

Ever since the Society assumed ownership of *Scientific Agriculture* in 1921, there have been frequent criticisms of its editorial policy. The two chief complaints were (1) that the majority of articles were too technical to be understood by the average member and (2) that certain branches of agriculture were not adequately featured in the journal.

Scientific Agriculture is the official organ of the C.S.T.A. At the time of its establishment it was made plain to every member that any original, well-written article would be published. There were no restrictions as to subject matter whatever. During the period between 1921 and 1927, when an average issue contained about thirty-two pages of reading matter, there was always a scarcity of suitable material. Many members who were known to be doing original work were publishing their manuscripts in other magazines. The journal of the C.S.T.A. was too popular in appearance and make-up. In 1927 *Scientific Agriculture* adopted its present form. An immediate influx of excellent articles forced an increase in the size of the journal from thirty-two pages of reading matter to sixty-four. Several issues have contained seventy-two pages, exclusive of advertisements.

The fact that the majority of articles have dealt with agronomy, genetics, bacteriology and entomology is not to be blamed upon the editorial policy. There is some excellent work being done in animal husbandry; many of the problems of agricultural education, extension and economics have been studied by C.S.T.A. members. The journal will publish any article submitted, provided it meets with the approval of the Editorial Board, and some of those who feel disposed to criticise the journal might be able to meet their own criticism by preparing an article and submitting it for publication.

It is worthy of note that in its present form *Scientific Agriculture* compares favourably with any scientific journal. It is looked upon as a Canadian contribution to the world's knowledge of agricultural science and any move to make it more popular in form or to broaden its editorial policy should be discouraged. Surely the professional men in Canada can support one journal of this kind and allow it to remain in the field of scientific literature. The nature of the articles which appear in it, and their subject matter, is entirely in the hands of the professional men themselves, and not to be attributed to a restrictive editorial policy, as some have intimated.

Notes and News.

W. T. G. Wiener (Manitoba '15) has been appointed Secretary-Treasurer of the Canadian Seed Growers' Association to replace P. Stewart (Toronto '14), resigned. The offices of the Association have been moved from Ottawa to the Manitoba Agricultural College, Winnipeg. Mr. Wiener was Cerealist at the M.A.C.

A. Leitch (Toronto '05), Professor of Agricultural Economics at the Ontario Agricultural College since 1920, has resigned to take charge of a tobacco-growing company in Norfolk County, Ontario. He will continue to reside at Guelph.

C. B. Nourse (Toronto '14) died at Maidstone, Sask., on October 19th, as the result of injuries received in a level crossing accident.

E. A. Western (Toronto '22) has changed his address to Lansing, Ontario.

E. D. McGreer (McGill '22) has joined the staff of the *Ontario Farmer,* Toronto, as Associate Editor.

T. C. McBeath (Alberta '28) is teaching science at the Agricultural School, Raymond, Alta., for the winter months.

M. P. Tullis, formerly Field Crops Commissioner for the Department of Agriculture in Saskatchewan, has been appointed Manager of the Saskatchewan Registered Seed Growers Limited, Moose Jaw, Sasak.

J. E. Britton (Toronto '14) has received the appointment of Assistant Superintendent at the Dominion Experimental Station, Summerland, B.C.

M. C. McPhail (Toronto '21), formerly Agricultural Representative at Stratford, Ont., has been transferred to Newmarket, Ont.

C. M. Meek (Toronto '22) has been appointed Agricultural Representative at Stratford, Ont.

L. A. Hietanen (Toronto '27) is attending the Ontario College of Education, Toronto. His address is 692 Spadina Avenue, Toronto 4, Ont.

A. E. Davey (Toronto '25) is now with the Dominion Seed Branch, 418 Winch Building, Vancouver, B.C.

C. A. Lamb (British Columbia '21) is teaching Agriculture and Science in the McLean High School, Port Haney, B.C. His mailing address is P.O. Box 68, Port Haney, B.C.

T. W. L. Burke (Saskatchewan '23) has changed his address to 2041 Athol Street, Regina, Sask.

J. B. Munro (Toronto '19), who has been for the past six years Assistant Agronomist for British Columbia, has received the appointment of Editor of *Farm and Home,* Vancouver, B.C.

J. Roy West (Manitoba '26) is attending the Ontario Veterinary College during the winter months. His address is 57 Cork Street, Guelph, Ont.

T. H. Jones, (Toronto '19) has resigned as Assistant in Fruit Transportation with the Dominion Fruit Branch at Vernon, B.C., and is now Lecturer in the Department of Horticulture, Ontario Agricultural College, Guelph, Ont.

L. H. Colbeck (Toronto '25) is Science Master at the High School, Fergus, Ont.

H. J. M. Fiske (McGill '14) has joined the staff of Messrs. W. J. McCart & Co., Wholesale Fruit Dealers, 74 Colborne Street, Toronto 2, Ont.

A. W. Peterson (McGill '21), who has been District Swine Grader in New Brunswick, has been transferred to Ottawa and is now Supervising District Inspector of Pure Bred Swine in the Dominion Live Stock Branch.

J. E. D. Whitmore (Toronto '26) has changed his address to Field Husbandry Department, Manitoba Agricultural College, Winnipeg, Man. He is Assistant Secretary of the Canadian Seed Growers' Association.

Wesley G. Smith (Alberta '25) has changed his address to Raymond, Alberta.

The following members of the Society have reported that they have registered for graduate work at the institutions named:—

F. E. Foulds (Toronto '16), University of Toronto, in Botany.

R. H. Bedford (Alberta '26), McGill University, in Bacteriology.

R. C. Russell (Saskatchewan '24), University of Toronto, in Plant Pathology.

Auguste Scott (Laval '27), University of Toronto, in Soil Chemistry (resident at Ontario Agricultural College).

F. J. Richardson (Toronto '26), University of Toronto, in Animal Physiology (resident at Ontario Agricultural College).

Kenneth Cox (Toronto '24), McGill University, in Agronomy (resident at Macdonald College).

F. Godbout (Laval '25), McGill University, in Plant Pathology (resident at Macdonald College).

L. T. Wilson (Saskatchewan '24), University of Wisconsin, in Agricultural Chemistry. Residing at 1124 West Johnson Street, Madison, Wis. Has resigned as Instructor in Animal Husbandry at the University of Saskatchewan.

W. G. McGregor (Toronto '24), University of Minnesota, in Genetics.

C. T. Tapp (Alberta '19), University of Alberta, in Agronomy.

W. A. Squires (New Brunswick '27), Ohio State College, in Zoology.

J. R. Pelletier (Laval '27), McGill University, in Agronomy (resident at Macdonald College).

Applications for Membership.

The following applications for regular membership have been received since October 1, 1928:—

Belzile, Roland (Laval, 1926, B.S.A.), St. Fabien, P.Q.

Broadfoot, W. C. (Minnesota, 1924 and 1925, B.S. and M.S.), Edmonton, Alberta.

Bruno, J. Hervé (Montreal, 1928, B.S.A.), Bramptonville, P.Q.

Crépeau, Omerille (Laval, 1927, B.S.A.), Montreal, P.Q.

Doxtator, Philippe (Manitoba, 1928, B.S.A.), Winnipeg, Man.

Ferron, J. Raynald (Montreal, 1928, B.S.A.), Sherbrooke, P.Q.

Gaudet, Bruno (Laval, 1927), B.S.A.), Ste. Anne de la Pocatière, P.Q.

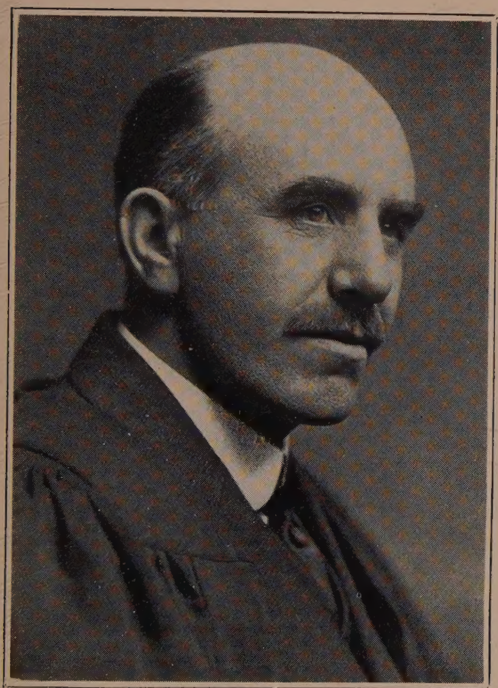
Geiszler, Gustav (North Dakota Agricultural College, 1928, B.S.A.), Saskatoon, Sask.

Girard, Hector (Laval, 1927, B.S.A.), Ste. Anne de la Pocatière, P.Q.
Granger, Philippe (Montreal, 1928, B.S.A.), L'Assomption, P.Q.
Marshall, W. B. H. (McGill, 1928, B.S.A.), Montreal, P.Q.
McGibbon, D. A. (McMaster, M.A., and Chicago, Ph.D.), Edmonton, Alta.
Paris, André (Laval, 1920) B.S.A.), Chandler, P.Q.
Ste. Marie, C. E. (McGill, 1928, B.S.A.), Montreal, P.Q.
Thorneloe, K. C. (British Columbia, 1928, B.S.A.), Vancouver, B.C.
Whiteside, W. (Toronto, 1928, B.S.A.), Guelph, Ont.
Young, R. S. (Alberta, 1928, B.Sc.), Edmonton, Alta.

Life Membership.

Henry E. Lefèvre, Canadian Manager of the N. V. Potash Export My., Montreal, P.Q., has made a payment of $100.00 to become a Life Member of the Society. He is the fourth member to take out life membership.

C. D. McGilvray.



Considerable publicity has already been given in the press to the annual meeting of the Ontario Veterinary Association, which was held at the Ontario Veterinary College on October 10th and 11th. A full report of the meeting, including a number of excellent papers and addresses, will be published by the Association in due course and mailed to the membership body and others who are interested.

To one feature of the programme we wish briefly to draw attention. As a token of appreciation for the service rendered to the veterinary profession, Dr. C. D. McGilvray, Principal of the Ontario Veterinary College, was presented with a silver tea service and an address. No one is more deserving of this recognition. The name of Dr. McGilvray has been a household word in veterinary circles for a good many years ant it is very fitting that after ten years in his present position, his popularity should be demonstrated in such a kindly manner.

The Canadian Society of Technical Agriculturists would like to see a closer contact formed between the veterinarians and the agriculturists, who have so many common interests, and if Dr. McGilvray can do anything to stimulate a movement of that sort, he will be adding one more accomplishment to a list which is already extensive.

Western Canadian Society of Animal Production.

A complete report of the second annual meeting of the above Society, held at Winnipeg last March, has recently been published. The officers of the Society for the current year are: President, J. M. Brown, Manitoba Agricultural College, Winnipeg, Man.; Vice-President, A. M. Shaw, University of Saskatchewan, Saskatoon; Secretary-Treasurer, Arthur Newman, Dominion Experimental Station, Lethbridge, Alta.

Local Branch Meetings.

Dr. E. S. Archibald, President of the Society, will attend local meetings from Ontario to the Pacific Coast on the following dates:—

Fort William, Ont.	January	21st.
Winnipeg, Man.	"	22nd.
Regina, Sask.	"	25th.
Saskatoon, Sask.	"	26th.
Edmonton, Alta.	"	30th
Calgary, Alta.	February	2nd.
Summerland, B.C.	"	7th.
Vancouver, B.C.	"	14th.

He will be accompanied as far as Saskatoon by the General Secretary. While in Winnipeg a special meeting will be held to consider the arrangement of a programme for the annual Convention of the Society which is to be held in that city next June.

The annual banquet of the O.A.C. Alumni Association and the C.S.T.A. will be held at the Board of Trade rooms, Royal Bank Building, Toronto, on Friday, November 23rd, at 6.30 P.M. Tickets can be purchased at the booth of the Canadian Co-operative Wool Growers Ltd., Royal Winter Fair.

The Western Ontario local has started its winter series of weekly meetings, the first two being held at Hart House, Toronto, on October 16 and 23.

The fall meeting of the British Columbia local is to be held at Vancouver on November 27th.

Monthly meetings of the Montreal local are to be held at the "Cercle Universitaire", Sherbrooke St. East. The first one, on October 20th, was very well attended.

The General Secretary will appreciate it if local secretaries will keep him fully informed regarding branch activities, so that these pages of the journal may be used to the best advantage.